Car owners' willingness to reside in a car restricted residential area

Master Thesis

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Technische Universiteit Delft

Car owners' willingness to reside in a car restricted residential area

A stated choice experiment to assess the effect of parking arrangements and the physical environment on the willingness of car owners to move to a car restricted residential area

By

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Preface

It may be odd for a person like me, not being able to choose between the simplest things in life to start a master thesis project based on people's choices. However, the public's perspectives on transitions and the way in which they could be included in the evaluation of policies appeals to me. Therefore, researching the public's opinion about car restricted residential areas seemed to be an interesting topic to study for my master thesis.

Before I invite you to read the thesis, first of all, I want to express my gratitude to all the people that have supported me throughout the research process. These past months I realised that working alone can be challenging, especially as it is in my nature not to ask for help. This means that their support was even more appreciated.

I want to thank the members of my graduation committee. Eric, thank you for sharing your extensive knowledge on stated choice models, your quick response to my questions and thorough reviews and critical feedback on my work. I think a graduate student cannot be more fortunate with someone that takes the time for his students and really tries to help you achieve your full potential. Furthermore, I want to thank Gerdien for her fresh perspective on my work and encouraging me to think about the bigger picture of my thesis. I want to express my gratitude to Chris and Lucas for being part of the warm welcome to the team earlier this year and your help during the last months. Lucas, thank you for pulling me out of the details when I lost track of the bigger picture. And Chris, thank you for your positive energy and advise. I think you both tried to support me in the best way you could and I really appreciate the practical knowledge you have facilitated me with.

A special thanks to the respondents for taking the time filling in the survey, showing interest in the topic and providing me with interesting discussions and interviews, which made me realise my interest in mobility transition and urban development even more.

Lastly, I would like to thank my family, friends and fellow interns for reviewing my survey and/or discussing or research topics. Discussing someone else's work was a pleasant change from contemplating my own work. And thank you, Tobias, for letting me use the only comfortable workspace I said our house 'would ever need' earlier this year.

Carmel de Nies,

Rotterdam, September 2020

Summary

Even though the Dutch average car driving distance per year is decreasing, car ownership in the Netherlands is increasing. Especially in cities, this forms an issue, as public space is scarce and room for parking space directly competes with sidewalks, bicycle paths, playgrounds, green areas, and recreational facilities. Meanwhile, the Dutch population is continuously growing, while there is already a housing shortage. Accordingly, municipalities are facing the issue of expanding their cities when public space is scarce. When developing conventional residential areas, establishing infrastructure for both driving and parked vehicles is very land-intensive. This means that further infiltrating cities in the way we are used to will conflict with public space, or, in case of, rural areas with nature and agricultural land. Therefore, building more residential areas while facilitating car parking in front of residences will be at the expense of the liveability and accessibility of the Dutch living environment. For this reason, a policy shift can be observed to restricting cars in (areas of) the city, which means that space which is normally assigned to car infrastructure can be used for other functions. Municipalities, therefore, perceive car restricted residential areas as an instrument to adapt to society's changing car use and simultaneously create more liveable, pedestrian-oriented cities with more public and recreational space. Living in a car restricted residential area will therefore imply not being able to park in front of a home. Yet this will be compensated with enhancements to public and recreational space.

Nevertheless, there is insufficient insight into how the physical environment should be designed to compensate for remote parking. By researching car owners' preferences for physical design characteristics of the living environment and parking facility arrangements in car restricted residential areas, their willingness to move to a car restricted residential area over a conventional residential area can be determined. The understanding of these preferences and the willingness of car owners to move to a car restricted residential area would support the design and development of car restricted residential areas. This research, therefore, aims to answer the following research question:

What is the effect of parking arrangements and the physical environment of a car restricted residential area on car owners' willingness to move to a car restricted residential area over a conventional residential area?

Methodology

A literature study was conducted to determine which design characteristics of a car parking facility and the physical environment influence the willingness to move to a car restricted residential area. A car restricted area in this study is distinguished as a visually car-free area, in which access to vehicles is restricted and car parking is either provided in-building, underground or at the edge of the neighbourhood, but there is no attempt to limit car use or ownership. The preferences regarding seven variables affecting car restricted residential choice were studied: (1) walking time to the car, (2) type of car parking facility, (3) monthly parking costs, (4) type of building, (5) liveliness level, (6) amount of facilities, and (7) the degree of green areas. A stated preference (SP) survey was used to determine which characteristics affect this preference, and to what extent. Car owners were asked to indicate their preference for designs of car restricted residential areas and accordingly if they would consider moving to the residential area of their choice over a conventional residential area. Furthermore, the survey contained questions to measure the influence of socio-demographic variables, car use, current residential environment, and attitudes towards car use, living environment and a car restricted living environment. The data of 257 respondents was used to estimate and interpreted a mixed logit (ML) model.

Findings

The research results suggest that only a few car owners prefer to live in a car restricted residential area over a conventional residential area, especially if they use their car daily or primarily for private

purposes. Furthermore, on average car owners do not prefer to walk several minutes to their car except households with children younger than 6 years old that may perceive longer walking times with a higher traffic safety grade. Likewise, most car owners do not like paying for parking their car, except people that are currently used to pay for residential car parking or currently park their car not more than 1 minute of walking from their home. Furthermore, people dislike a neighbourhood in which there is hardly any activity of people on the streets or a neighbourhood in which the green area only comprises one big central park. Supporters of car restricted residential areas like a neighbourhood containing only a supermarket, while there is an aversion to the offer of a small range of facilities such as a bakery, flower shop and cafés additional to a supermarket. Overall, the walking time to and monthly price for parking significantly decrease the willingness to move to a car restricted residential area, while the physical environment of a car restricted residential seems to be of less importance. This implies that improvements to the physical environment should be traded off carefully to the location and price of parking facilities. Lastly, the results indicate that residence owners are, opposite to residence renters, more willing to move to a car restricted residential area.

In terms of traffic safety, traffic nuisance, presence of footpaths, bicycle infrastructure and presence of green areas the expectations of car restricted residential areas are very high. Nevertheless, these expectations, just as attitudes towards car use and quality of the living environment, did not seem to influence the willingness to move to a car restricted residential area.

The willingness of car owners to move to a car restricted residential area according to several designs was determined, to gain knowledge of the different attractiveness levels of certain designs. Overall, the willingness of car owners to move to a car restricted residential area is low and most people seem to prefer to live in a conventional residential area. Spaciously designed car restricted residential areas, characterised by higher levels of green space and lower levels of liveliness, are less attractive to car owners. Compact car restricted residential areas, however, seem to be slightly preferred amongst car owners, which may be due to their higher levels of liveliness, higher contributions of high-buildings, and lower levels of green areas.

Recommendations for policymakers (municipalities)

For municipalities considering developing a car restricted residential area, the main recommendations are the following: (1) Do not assign to much value to a car restricted residential area, at least not in terms of the physical environment since only a few car owners would prefer to move here over a conventional residential area. (2) Consider the locations of the car parking facilities carefully since longer walking times exponentially decrease the willingness to move to a car restricted residential area. (3) Only introduce car parking costs if necessary, as only a few will be willing and able to pay for car parking. (4) It is not essential to facilitate private parking spaces, a public parking garage will suffice. An additional benefit of a public parking facility is the opportunity for shared usage to enable an increased overall occupancy rate per parking space, which may be essential when public space is scarce. Shared usage may not only optimise parking but may also increase the parking's revenue and thus may reduce the car parking costs for residents. (5) Consider a car restricted residential area in case, due to limited space, a compact design is required. (6) Establish an adaptive design of car parking facilities that allows adapting to a possible shift from car ownership to car sharing. The design of car parking facilities should, therefore, incorporate the flexibility to transform into a mobility hub or to be assigned to different functions, e.g. retail facilities.

Recommendations for future research

The main recommendations for future research are the following: (1) Perform additional qualitative research to increase the understanding of people's association towards car restricted residential areas. (2) Develop a hybrid choice model to research the influence of attitudes on the preference for the design variables and moving to a car restricted residential area. (3) Develop an integrated conjoint choice model to include more aspects of the neighbourhood and thereby resemble the residential location choice behaviour of people better. (4) Perform the same stated choice experiment with another sample to see whether the degree of willingness to move to a car restricted residential area is comparable to what has been found in this research.

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1
Introduction

This chapter will discuss the observed housing shortage and accordingly the introduction of car restricted residential areas to create more liveable cities (Section 1.1). However, it is noted that current knowledge on the attractiveness of these areas among car owners is limited (Section 1.2). Hence, several research questions are drafted to understand the preferences of car owners regarding car restricted residential areas (Section 1.3). By answering these research questions this research aims to enhance the knowledge on this topic which may be relevant for both practise as academically (Section 1.4). Lastly, this chapter will describe the further content of this report (Section 1.5).

1.1 Research context

Nowadays the average kilometres per year driven by the Dutch population decreases, while the car ownership in the Netherlands increases (CBS, 2019a). This forms an issue, especially in cities, where public space is scarce and room for parking space directly competes with the realisation of sidewalks, bicycle paths, playgrounds, green space or terraces since many municipalities consider these together with parking facilities to be an integral part of public space.

Meanwhile, the Dutch population is continuously growing and since there is already a housing shortage, 845.000 residences should be realised the coming 10 years to facilitate this increase (Rijksoverheid, n.d.). Considering the trends of the Dutch population of present car use and car ownership, this development may, especially in dense urban areas like cities, propose an issue, as the current car infrastructure within cities is not adequate to facilitate a higher number of cars (CBS, 2019a; KiM, 2018). For multiple municipalities, this proposes issues regarding maintaining the accessibility of their cities (Melchers, 2018; Van Oort & Van Haaren, 2019). Not only will the streets congest, but more traffic will also make a city less attractive for living and recreating, as both driving and parked cars portray the city's street scene. Especially as cities generally form the places where most of the country's population concentrates, these effects form a challenge to municipalities in maintaining both the liveability as the accessibility (Gemeente Rotterdam, 2019; Vissers, 2019). Thus, developing new residences will require establishing infrastructure for both driving and parked vehicles, which is very land-intensive (Marsden, 2014). This implies that further infiltrating cities in the way we are used to will collide with public space. Likewise, in rural areas, the development of accompanying car infrastructure will compete with nature and agricultural land.

For these reasons, when municipalities allow their cities to grow without restricting vehicle access or parking, this will be at the expense of the liveability, sustainability and health of the city and its citizens. Therefore, the changing objective of many municipalities is more public space and fewer cars on the street. Hence, currently, a policy shift can be observed in the Netherlands. In Amsterdam, 10.000 parking spaces will be abolished, in Rotterdam, the parking tariffs for residents are raised, and in Utrecht, a residential area is developed with a restricted number of parking spaces (Gemeente Utrecht, 2020; M. Koops, 2019; R. Koops, 2019).

Thereby the Netherlands is following the example of multiple European cities that are downsizing the number of parking facilities in city centres and residential areas. By introducing car restricted areas, cities such as Hamburg, Helsinki, Madrid and Oslo all restrict car movement and/or parking within certain areas and introduced car parking at the periphery of these areas (Cathcart-Keays, 2015; Groot, 2018).

Car restricted residential areas are therefore perceived as an instrument to create more liveable and pedestrian-oriented cities including more public and recreational space (Scheurer, 2001). The design of these car restricted housing projects is exceptional in a way that instead of arranging parking spaces adjacent to residences, the settlement's design distinguishes itself in the limited, peripheral, and concentrated parking facilities. This induces that residents, in comparison to most conventional residential areas, have to spend more time to reach the parking facilities.

The prospect of not being able to park near residences, however, faces both resistance as support from political parties in a municipality and their residences (Redactie Rotterdam, n.d.; van Eijck & Naafs, 2019). In particular, real estate developers are afraid that there is a low demand for residences in car restricted neighbourhoods. To assess the influence of vehicle restrictions on the preference for a car restricted residential area, Borgers et al. (2008) researched how people can be compensated for parking remotely from their residences. Their study found that an important condition for introducing remote car parking is that the parking facility should be safe and that public transport facilities should be improved. Nevertheless, people prefer parking their cars adjacent to their residence. Additionally, Borges and Goldner (2015) studied the socio-demographic characteristics that are related to the willingness to live in a car restricted residential area. Their research observed that mainly younger people, households with children and people that frequently use a bicycle or walk are more willing to move to a car restricted residential area. Lastly, Gundlach et al. (2018) found in their research determining the willingness to live in a car restricted residential area that the overall willingness to live in a car restricted residential area is high. Nevertheless, important conditions to the attractiveness of these neighbourhoods are that the public transport fee should be reduced, bicycle infrastructure should be improved, and streets should be dedicated to recreational areas.

1.2 Knowledge gap

Thus, so far, the relation between transport facilities and the willingness to park remotely in car restricted residential areas is researched, as well as the influence of transport facilities and socio-demographic characteristics on the preference for living in a car restricted residential area. However, when considering the design of a car restricted residential area and the fact that cars in this design do not shape the street scene, an urban design issue remains about what it is that should shape the street scene of these residential areas. As described, currently, knowledge is lacking on how remote car parking will be received by residents in relation to the physical environment that a car restricted residential area may offer, and how different designs will affect the overall willingness to move to a car restricted area. A study performed by the National Institute for Public Health and the Environment (RIVM) indicates that a liveable or high-quality residential environment should meet the requirements of its residents as much as possible. Furthermore, its residents should find it pleasant and attractive to live in and develop activities there. Moreover, the study shows that the (subjective) valuation of the residential environment by its residents is determined by various (objective) characteristics of the physical and social environment (Leidelmeijer & van Kamp, 2013). The valuation of a residential area, therefore, is more than a summation of objective quality and valuation of sub-aspects and thus is more perceived as a perception and assessment of the area as a whole. This means that the parking situation in a residential area does not only externally affects the quality of life and the quality of the living environment, but at the same time, it is an integral part of the quality of life and quality of the residential area. However, the influence of the physical design characteristics and the car parking arrangements on a car owner's willingness to move to a car restricted residential area has not been researched yet. In order to advise on the design of a car restricted residential area, it is proposed in this research to study the trade-off between remote car parking and the specific physical environment characteristics that a car restricted residential area can offer. Moreover, this study aims to determine their influence on the willingness of car owners to move to a car restricted residential area.

1.3 Research questions

This research aims to fill the identified knowledge gap. The knowledge gap outlined in Section 1.2 is therefore translated into the following main research question:

What is the effect of parking arrangements and the physical environment of a car restricted residential area on car owners' willingness to move to a car restricted residential area over a conventional residential area?

In order to answer the main question, the following sub-questions are formulated:

- *What is the effect of different design variables on the willingness to move to a car restricted residential area?*
- *What is the relation between the distance to a car parking facility and the physical design variables of car restricted residential areas?*
- *What is the effect of socio-demographic variables, car use, current residential environment, and attitudes on car restricted residential areas on the willingness to move to a car restricted residential area?*
- *What are the current attitudes of car owners towards a car restricted residential area?*
- *To what extent do car owners prefer moving to a car restricted residential area over a conventional residential area?*

1.4 Relevance

The answers to these questions will provide insights that may have a scientific as well as a societal contribution.

1.4.1 Social relevance

The knowledge gained by this research will provide insights into the development of car restricted residential areas in the Netherlands. Thereby providing municipalities and project developers with suggestions for developing an attractive design of such areas in various parts of the Netherlands. Since the costs for real estate developers for realising car parking facilities underground or in-building are very high, it is important to determine the willingness among car owners for moving to a car restricted residential area. Researching car owners' preferences regarding the design variables of a car restricted residential area will, therefore, provide some valuable insights. These insights will provide an understanding of how remote car parking can be compensated with certain physical characteristics. Furthermore, the knowledge of the preferences of car owners regarding several design variables of car restricted residential areas allow to determine the willingness to move to a car restricted residential area over a conventional residential area according to different designs. In this way, recommendations to municipalities and project developers can be provided on the effects of certain designs of car restricted residential areas on the willingness to move for car owners. Furthermore, this research will provide an indication of which segments of people will be more likely to move to a car restricted residential area over a conventional area. Lastly, understanding car owners preferences towards walking time to a car parking facility may be a first step towards the introduction of mobility hubs in neighbourhoods. This might be important because in general, the concentration of functions on central locations within an area requires people to cover some distance from their home.

1.4.2 Scientific relevance

The current literature provides insights on how people trade-off living in a car restricted residential to the transport infrastructure offered as well as which segments of people are willing to move to a car restricted residential area. This study will contribute to that literature by providing new insights on how people trade-off parking arrangements and physical environment characteristics in car restricted residential areas. Additionally, the literature addresses car restricted residential areas as an instrument to increase the liveability of a neighbourhood. At the same time, it is argued that the physical environment is an integral part of the quality of life in a residential area. Therefore, it would be useful to see how people value the physical living environment of a car restricted residential area.

1.5 Report structure

The research's context, objective and research questions are described in this chapter (Chapter 1). The following chapter (Chapter 2) will elaborate on the methods that are used to answer the research questions. Subsequently, the review of literature on residential location choice, characteristics and developments of car restricted residential areas and preferences regarding car restricted residential areas will be outlined (Chapter 3). The knowledge gained by the literature review will be used to establish the design of the survey that will be dispersed among car owners (Chapter 4). The following chapter will describe the characteristics of the people that filled in this survey (Chapter 5). The data collected with the survey will thereafter be used as input for the estimation of the discrete models (Chapter 6). Subsequently, the estimation results will be interpreted to gain an understanding of the preferences of car owners regarding several design characteristics of car restricted residential areas (Chapter 7). This knowledge will be used to predict car owners 'willingness to move to a car restricted residential area for different designs of car restricted residential areas (Chapter 8). The insights of this research will thereafter be concluded and discussed (Chapter 9) where after the process of performing this research will be reflected and supplemented with recommendations for future research (Chapter 10).

2

Methodology

Different methods are applied to provide answers to the prior defined questions. This chapter discusses how the literature review is used to gain an understanding of people's residential location choice behaviour, more specifically on their preferences regarding car restricted residential areas (Section 2.1). Furthermore, the method used to determine the preferences regarding characteristics of car restricted residential areas will be described (Section 2.2), moreover the method will be outlined which are used to determine latent attitudes that may influence people's willingness to move to a car restricted residential area. (Section 2.3). This chapter will provide an overview of the methods applied in this research in the last section (Section 2.4).

2.1 Literature study

First, a literature study is performed to gain an understanding of residential location choice behaviour, current developments regarding car restricted residential areas and people's preferences towards living in a car restricted residential areas. The review is used to identify which variables determine how people value a residential area when looking for a new house. Furthermore, literature on the development of car restricted residential areas is reviewed. The knowledge of residential choice behaviour and car restricted residential areas is then used to determine which effects on the willingness to move to a car restricted residential area have not been studied yet and would be interesting to study in this research.

2.2 Discrete choice analysis

In transportation and marketing research, stated choice modelling is a commonly applied method to measure individual preferences. Moreover, this method is also used to assess people's preferences for housing type and location choice (Koppelman & Bhat, 2006). Discrete choice analysis allows observing and predicting individuals' choices from a set of alternatives. In this way, the influence of different design aspects of the residential area on the decision to move to a car restricted residential area can be determined. Stated choice data, therefore, provide information on the influence of design changes on the attractiveness of a residential area from the perspective of the (potential) residents. Knowledge of these influences will support optimising the designs for car restricted residential areas (Koppelman & Bhat, 2006).

At first, a description will be provided that discloses how the required data is gathered with a stated preference survey (Section 2.2.1). Subsequently, an explanation is given of the analysis of the data through discrete choice models (Section 2.2.2.). The assessment of the exploratory power of the model will be outlined in Section 2.2.3. Lastly, a descriptive summary of stated choice experiments is provided in Section 2.3.4. The construction of the stated choice experiment is outlined in Chapter 4.

2.2.1 Data collection by a stated preference survey

The data will be collected through a survey. In discrete choice analysis, two data types can be distinguished: stated preference (SP) data and revealed preference (RP) data. This study uses stated preference data instead of revealed preference data. The substantial advantage of the SP data collecting method is that persons make decisions within predefined choice sets, which allows studying hypothetic situations, and therefore is ideal to test future situations (Train, 2003). Moreover, SP experiments are in general easier to control, allow more flexibility and are less expensive (Molin, 2018). A more detailed description of the advantages and disadvantages of both data collecting methods is provided in Appendix B.

The collected data forms the input for the decision models and will be used for estimating people's preferences between a predefined set of alternatives. The values of multiple design variables are altered over multiple alternatives. These alternatives are systematically variated over choice sets, which will be presented to people. In each choice set, an individual is asked to select their preferred residential area. The moderate changes in the designs of the presented alternatives enable determining people's trade-offs between characteristics of the living environment and car parking arrangements. This way of collecting data is straightforward and at the same time, allowing to gather multiple observations from an individual, which results in larger sample sizes (Molin, 2018).

The stated choice data will be accumulated through a digital questionnaire (see Appendix E). This survey will be dispersed among Dutch car owners (Section 4.4 will elaborate more on the selection of the sample). In the survey, an introduction of a car restricted residential areas and an explanation of the choice experiment are provided. Thereafter, various choice sets are presented to the respondents. Each choice set consist of two designs of residential areas which vary regarding their attributes (i.e. de design characteristics of the residential area). The selection of attributes that will form the alternatives will be selected through a literature review (see Chapter 3). In each choice set respondents are requested to select which of the two residential areas they prefer. Thereupon, respondents are presented with the question to consider if they are willing to move to the residential area they selected in the first question. The construction of the choice set will be described in Chapter 4.

2.2.2 Data analysis with discrete choice models

Discrete choice models allow analysing the choice behaviour of persons. These models are able to reveal to what degree the design variables affect the decisions of an individual (Koppelman & Bhat, 2006). The models used in this research will estimate the choice behaviour of persons according to the random utility maximisation (RUM) theory. This theory implies that individuals will select the alternative that, according to them, yields the most utility (Walker & Ben-Akiva, 2002). Utility indicates the value a person obtains from the attributes of an alternative (Koppelman & Bhat, 2006, p. 14). The stated choice experiment used in this research will contain three alternatives: residential area (1), residential area (2) and (3) a conventional residential area (base alternative). These alternatives each have different utility functions that determine the utility per alternative. The total utility (U) that an individual derives of an alternative (i) includes two elements: the systematic utility (V_i) and the error term (ε_i). The systematic utility of an alternative is formed by the summation of the utilities corresponding to the attribute levels of that specific alterative. However, a researcher cannot measure all the variables that are influencing people's choice behaviour, nor does a researcher know which specific variables the decision-maker takes into account when choosing between alternatives. For this reason, the error term is introduced that is able to capture the difference between the observed utility and the actual utility people derive from an alternative (Train, 2009). The theory of a discrete choice model is outlined in more detailed in Appendix B.

The total utility of the set of alternatives is used to determine the probability that an individual will choose a certain alternative over other alternatives of this set. The calculation of this choice probability is dependent on the model that is used, as different models make different assumptions about the probability distributions of the error term (ε).

A multinomial logit (MNL) model will be estimated first. The model which was introduced by McFadden (1974), is nowadays most commonly used and is mainly favoured due to its simplicity. The formula which is used to calculate the choice probabilities is closed form, which makes the model simple to estimate (Train, 2009). This is due to the model's assumption that the error terms corresponding to the alternatives are all distributed equally and are independent of each other (i.i.d. assumption). With these assumptions, error terms are drawn and assigned independently across alternatives. This means that each error term is completely uninformative of all other error terms. This assumption, therefore, ignores the correlations within 'nests of alternatives' and between choices conducted by the same person over time (Louviere, 1988; Train, 2009). This leads to biased estimation of outcomes.

To overcome this drawback, secondly, a mixed logit (ML) model is estimated. An ML model consists of three main aspects that counterbalance the prior described limitations of the MNL model (Hensher & Greene, 2003). The first advantage of the ML model its ability to seize nesting effects, meaning that it captures correlations between similar alternatives and choices. Secondly, the ML model assumes that preferences for different attributes vary across people and within segments. The correlation between alternatives and heterogeneity across individuals will be captured in unobserved utilities (υ). Lastly, an ML model captures the correlation between choices performed by the same individual, as a person choosing the alternative with the least walking time to the car parking facilities in the first choice set will presumably choose for the alternative with the least walking time in the second to the last choice as well. Thus, in case alternatives have similarities in one or more factors, there is a correlation between the choices one individual makes, or if there are heterogeneous preferences concerning attributes, an ML model will outperform an MNL model, as it allows to randomly vary utility in terms of these dimensions (Hensher & Greene, 2003). For this reason, this research will estimate an ML model after the MNL model to assess whether it is able to fit the data better. Nevertheless, an MNL model will be estimated first, as it a straightforward model and quicker to estimate. The model that fits the data best will be interpreted and used to answer the research questions (Appendix B can be consulted for a more detailed description of the theory).

2.2.3 Summary of the stated choice experiment

Several choice tasks between two residential areas are presented to respondents. These residential areas differ in the design of car parking and physical environment, such as the type of building in the surrounding area. For example, in residential area (1) only high-rise buildings can be found, while residential area (2) is composed of a mix of high and low-rise buildings. Provided with this information, the respondent is asked to select their preferred residential area. Subsequently, the respondent is presented with the situation of having to move within 6 months, and the choice to either move to the former selected residential area (area (1) or area (2)) or a conventional residential area. The respondent is presented with multiple of these choices. This produces multiple observations of choices that respondents have made between two residential areas and the base alternative of moving to a conventional residential area. These observations can be analysed by mathematical models which allow deducing to what extent the different characteristics of car restricted residential areas determine the choices of respondents. For example, it is possible to determine the extent to which the amount of green in a residential area influences the respondent's choice between two residential areas and how this relates to their preference considering the walking time to the parking facilities. This makes it possible to determine the relative importance of characteristics on the choice. These insights can be used to predict the outcome of choices of respondents for additional designs of car restricted residential areas. Since respondents are asked to choose between moving to the selected residential area and moving to a conventional residential area, it is possible to predict, for a residential area with a specific design, how many people would be willing to move to the residential area and how many people will not.

An MNL model can be used to reveal the preferences regarding aspects of these residential areas and to predict the willingness to move to residential areas with certain characteristics. Nevertheless, an MNL model has some considerable drawbacks, as it assumes that every single observation is not correlated. Meaning that the choices made by the same respondent are assumed to be independent of each other. As in reality, respondents that preferred to walk as little as possible to the car parking facilities are likely to prefer this in all the choices that they will make. Furthermore, an MNL model does not assume alternatives with similar variables to be correlating. And lastly, the model assumes that people possess the same preferences considering design variables. An ML model can be used instead to avoid these drawbacks.

2.3 Exploratory factor analysis

Additional to the discrete choice analysis, a factor analysis will be carried out. Because it is likely that in addition to the former mentioned observed variables that will be measured in the survey (such as walking time to car parking facilities, people's current car travel behaviour, current residential environment and socio-demographic characteristics), unobserved factors such as attitudes towards living in a car restricted residential area could influence people's choices as well. However, an exploratory factor analysis will be carried out, as attitudes are, in general, often implicit and not easily measured directly. This analysis allows exploring the underlying factors that influence choice behaviour.

2.3.1 Data collection: statements

Different statements will be used to measure people's explicit attitudes toward car use and living environment. For each statement, respondents are requested to express to what extent they (dis)agree with the presented statement by rating their (dis)agreement on a Likert scale (Likert, 1932). To allow people having a neutral opinion, an uneven number of levels will be applied, which allows people to select a neutral option. However, the neutral alternative does not provide any information for the research and is therefore in some cases also eliminated (Hartley, 2014). Another option to avoid people to select the neutral option too frequently or easily is by selecting a scale which is higher than a 3 or 5 point rating scale (Matell & Jacoby, 1972)Moreover, adding more levels of scale will increase the level of detail that can be obtained from the responses. Nevertheless, it may be difficult for respondents to express their genuine feelings at such a level of detail (Russell & Bobko, 1992). Since the stated choice experiments already demand much effort of the respondents a 5-point rating scale is selected in this research, in which 1 indicates *totally disagree* and 5 stands for *totally agree* with the statement.

2.3.2 Data analysis: factor analysis

These statements are then analysed to identify underlying attitudes that could influence the choice behaviour of people. Factor analysis allows identifying the underlying structure of a set of measured variables (Williams, Onsman, & Brown, 2010). By analysing the correlation between the statements, a factor analysis summarises the statements by providing a new factor structure. Each factor of the factor structure can be interpreted as an underlying factor (Habing, 2003; Rietveld & van Hout, 1993). The simplified factor structure facilitates obtaining a coherent overview of the measured data. Besides, the output of the factor analysis provides the advantage of employing in subsequent analysis (Field, 2000). A comprehensive description of the theory of the factor analysis is outlined in Appendix B.

2.4 Conclusion

In this research fist, a literature study is performed to gain an understanding of people's residential location choice behaviour and more specifically the preferences regarding and specific characteristics of car restricted residential areas. Furthermore, a stated preference survey will be drafted including a choice experiment to gather data that can be analysed by estimating discrete models. A multinomial logit model will be estimated which will be followed by estimating a mixed logit model, as this model is able to overcome several limitations of the multinomial logit model and capture nested effects, panel effects and taste heterogeneity. Furthermore, the survey will be supplemented by several statements that will be used to determine latent attitudes that may have an influence on people's choice behaviour.

3

Literature study

This chapter describes the performed literature study to gain an understanding of people's residential location choice behaviour, current developments regarding car restricted residential areas and people's preferences towards living in a car restricted residential areas. The review is used to identify which variables influence people's preferences in the process of looking for a new house (Section 3.1). Additionally, literature on the development of car restricted residential areas is reviewed, to gain an understanding of the specific characteristics of a car restricted residential area that may affect car owners' preferences towards these residential areas (Section 3.2). Furthermore, previous studies on the willingness to move to a car restricted residential area will be reflected. The insights about residential choice behaviour and car restricted residential areas which are combined and used to determine which variables influence car owners' willingness to move to a car restricted residential area and which have not been studied yet and would be interesting to study in this research (Section 3.4). This knowledge is used to further demarcate the research (Section 3.4). The chapter will conclude with the insights gained by the review which will be used to establish the survey design in Chapter 4 (Section 3.5).

3.1 Residential location choice

The theory underlying choice behaviour is the random utility theory. People thus, try to maximise the utility derived from an alternative. When choosing where to live a people will consider which residential area will provide the most benefit to them. For this reason, it is important to understand how people select a residential area.

Most researches study the influence of objective factors, such as affordability and accessibility on people's residential location choice behaviour. This implies that residential choice is solely based on objective criteria (J. H. Kim, Pagliara, & Preston, 2005). However, others state that next to rational motives, also irrational motives influence residential choice (Levy, Murphy, & Lee, 2008; Munro, 1995). By interviewing real estate agents, Levy & Lee (2011) identified that residential location choice is based on three kinds of preferences: (1) property-specific preferences, (2) location preferences and (3) personal preferences. These three are all composed of rational and irrational (social-psychological) variables. The residential location choice of people will therefore be explained according to these themes.

3.1.1 Property-specific preferences

Rational preferences: Characteristics of the residence

At first, **residential characteristics** such as the price, type of house, property's size, number of bedrooms, parking on the property, presence and size of the backyard influence how people value a residence (Levy & Lee, 2011; Molin et al., 1996; Pagliara, Preston, & Simmonds, 2010). Moreover, in the study of Levy and Lee (2011) real estate agents mention the effect of investment potential to affect the residential choice.

Furthermore, the supply of properties seems to influence residential choice (Nurlaela & Curtis, 2012) and Curis, 2012). Scheiner (2010) indicated that limited **residential supply** limits households in their selection process. Likewise, Molin et al. (1996) and de Vos et al. (2012) mention insufficient housing alternatives and **housing prices** affecting the choice for the residential location of households. Similar studies observed that **affordability** is a significant indicator of choosing a new residential location (Frank, Saelens, Powell, & Chapman, 2007; Næss, 2014; Nijskens et al., 2019), whereas Lin et al. (2017) mention that the number of alternatives, indicating the freedom people have affects the selection process.

Emotional preferences: Property's ability to reflect its occupant's status

The ability of a residence to reflect its occupant's **status** is stated by real estate agents to be of importance when buying a house (Levy & Lee, 2011). This form of **place-identity**, referred to as place identity of a place, implies that the objective characteristics of a property influence how people subjectively value its identity (Peng, et al., 2020; Proshansky, 1978). For example, in the study of Levy and Lee (2011) real estate agents stated views and the type of houses to be factors for representing status and therefore significant influences of moving to a specific house.

3.1.2 Location preferences

Rational preferences: Physical design and neighbourhood's accessibility

Next to residence specific characteristics, neighbourhood characteristics are observed to be a determining factor when modelling household's residential choice (Gayda, 1998; Nurlaela & Curtis, 2012; B. Walker, Marsh, Wardman, & Niner, 2002). McCormack et al. (2019) found that the criteria for selecting a residential location included: the **accessibility of public transport,** the **offer of retail or other services**, **presence of recreational facilities**, **proximity to the (city) centre**, **distance to employment**, **proximity to educational facilitie**s, the **connection to highways** or major roads, and the **availability of community associations**. Furthermore, this research concluded that important indicators of selecting a specific residential area were **attractive and proper streets**, a **variety of building types**, and the **presence and quality of recreation facilities** and **green areas**. Considering pedestrian-oriented residential areas, Brookfield (2016) observed that **local facilities**, social interaction, **noise**, **green space** and **density** were determining factors in selecting the residential location. Tu and Eppli (1999), even concluded that in comparison to conventional suburban residential areas, residence purchasers were willing to pay more for similar homes in higher density, mixed-use, pedestrian-friendly residential areas. Nevertheless, the research of Jarass and Scheiner (2018) found that inhabitants of residential areas in Berlin that possess equal characteristics did hold different preferences towards transport modes and residential locations, indicating the physical structure does not significantly affect the residential location selection.

Emotional preferences: Social network and social value

Next to the objective criteria of a location, it is discussed that the social aspect of residential choice is an important factor in determining where to live (Ettema, et al., 2011). Results of a study by Guidon et al. (2019) have found that the **proximity to friends and relatives** is generally traded off against commute time. Personal networks are found to significantly affect residential choice, even more than the proximity to employment (Belart, 2011). Van de Vyvere et al. (1998) have included the proximity to friends and relatives in a discrete choice model and their results have shown that respondents preferred to live close to their contacts, however not too close. The last was assigned to the potentially negative perceived social control that is accompanied by living too close to social contacts. Likewise, Stokenberga (2019) studied via a stated preference experiment the influence of family networks on residential location choice and found that people living in Bogotá (Colombia) that have received help in the form of childcare and help in crises were more likely to live close to family. Likewise, Fischer and Malmberg (2001) and Karsten (2007) have found that especially families with children tend to move close to their social network.

Furthermore, Kasten (2007) and Butler and Robson (2001) have found that people have the preference to live **close to like-minded people** as a result of sustaining homogeneous social networks in terms of social class and ethnicity.

Lastly, **social value** seems to affect residential location choice. Levy and Lee (2011) have found that residential areas often have unique identities that will attract like-minded people who relate to these specific identities. Also here place-identity appears to be of importance, the **place identity of a place,** in this case, implies that the objective characteristics of a residential area affect how people perceive its identity (Peng et al., 2020; Proshansky, 1978). For example, a residential area in which a high number of households with children live and consists of multiple playgrounds can be perceived as a child-friendly neighbourhood and therefore may attract households preferring to live in a child-friendly neighbourhood. Moreover, living in a specific area may be accompanied with **status**, as material possessions in today's society in most cases are a representation of people's wealth and status (Dittmar, 1994), the residence and the residential area where people live may therefore represent people's prominence. Furthermore, the **safety** of a neighbourhood is found to be an important indicator of choosing where to live (Frank et al., 2007; Næss, 2014). This may also be the result of the presence of objective characteristics such as the presence of street lighting. Moreover, people seem to base their choices on previous choices made by other households. Dugunji and Walker (2005) and Paez and Scott (2007) let the value of their attributes vary depending on the previously made choice of others. By introducing this, these studies noted that **copying** the **behaviours**, preferences or valuations of other households is considered to be a useful strategy for optimising the outcomes of their choices.

3.1.3 Personal preferences

Rational preferences: Socio-demographic variables, life cycle events and current residential location

Several studies indicate that next to residence-specific preferences and location preferences, socio-demographic characteristics affect residential choice behaviour (Buehler, 2011; Ewing & Cervero, 2010; Næss, 2012). Humpreys and Ahern (2019) concluded that even though transport is a significant factor in the residential choice, for most people it is not the main determinant. Their study found the location selection to be more dependent on respondents' characteristics, such as **age**, **gender**, type of **employment** and **income**. Additionally, Sermons and Koppelman (1998) indicated the relation between **household type** and residential location. Correspondingly, Liao et al. (2014) observed the likelihood for having a strong preference for compactly designed residential areas is higher for households with a minor number of school-age children, low incomes, rent their house, or who prefer social interaction and possess a limited need for privacy. Likewise, de Vos and Alemi (2020) concluded that people between 35 and 46 years old and households with **children** prefer living in suburban areas to urban areas.

Other studies showed the effect of **life cycle events** such as change of employment, change of education and changes in household structure to influence the residential choice (Blossfeld & Blossfeld, 2015; Oakil, Ettema, Arentze, & Timmermans, 2014; Yu, Zhang, & Li, 2017; J. Zhang, Yu, & Chikaraishi, 2014). By using a random-effect discrete choice model, Warner and Sharp (2016) concluded unanticipated and disruptive life events, such as marriage, divorce, parenthood, homeownership, employment, college and unemployment, to significantly affect the intention to move.

Furthermore, one of the main factors that related to the forthcoming residential preference found by Choocharukul et al. (2008) was, next to socio-demographic variables, the **current residential location** of respondents. Additionally, Kim, Pagliara and Preston (2005) concluded that alternative residential locations resulting in improvements considering supermarkets, educational facilities, transport time and transport costs improve the likelihood of moving.

Emotional preferences: Lifestyle, personal perspectives and experiences

Considering the behavioural aspect, households may not only select their residential location based on their current situation, but people's previous experiences and planned intentions are also found to influence this choice as well (Giele & Elder, 2014; López-Ospina et al., 2016). Furthermore, the residential choice is affected by another form of place-identity, referred to as **people's place identity**, referring to the identification of individuals with a place. It is argued that this form of place identity, reflected in people's **personal experience** and **familiarity** with a residential area, is an important influence in the connection people have with a neighbourhood and therefore tend to determine where people prefer to live (Levy & Lee, 2011).

Furthermore, people's **lifestyle** is an important determinant of the selection process. An important aspect of lifestyle is formed by **travel behaviour**. Residential self-selection (RSS) forms an important factor within this selection process. This term implies that households move to residential areas that provide the conditions that correspond to their travel needs and preferences (Cao, Mokhtarian, & Handy, 2009; Choocharukul et al., 2008; Ettema & Nieuwenhuis, 2017). Humphreys and Ahern (2019) observed in their research that travel behaviour significantly influences the selection of a residential area. However, their results indicated that these patterns are not the only consequence and that conversely, respondent specific characteristics such as income, household size and age determine this choice to a greater extent. Likewise, Ettema and Nieuwenhuis (2017) found that attitudes towards travel modes and residential location choice are related to a limited extent. Their results indicated that only frequent train users relocate to residences close to central stations. However, not all residential locations are interrelated with the dependency on certain travel modes, as people living in rural areas rely more on cars to conduct their daily activities (Khattak, Rodriguez, & Khattak, n.d.; Schwanen & Mokhtarian, 2005a, 2005b). This is supported by Paleti, Bhat & Pendyala (2013) who have found that choices of residential locations relate to vehicle ownership. Additionally, it is observed that the possibility of reducing travel costs and travel time to activities positively influences the willingness to move to a certain residential location (Kim et al., 2005; Tillema et al., 2010).

Residential location choice is also related to **personal perspectives** on environmental protection and policies for urban growth. Furthermore, Paleti et al. (2013) concluded that **attitudes** and **lifestyle preferences** significantly affect these decisions, as people with greener or non-automobile-oriented lifestyles are likely to locate in higher-density residential areas. Choocharukul et al. (2008) found that people possessing pro-car attitudes let this affect their residential location choice. Nonetheless, Bohte (2010) concluded that the residential locations of many households were not corresponding with their location-specific preferences. Furthermore, this study found that people with an environmental attitude attach more value to the distance to green areas.

3.1.4 Conceptual framework of residential location choice

Concludingly, people's preferences, which according to the literature, are determining residential choice behaviour are summarised in Figure 3.1.

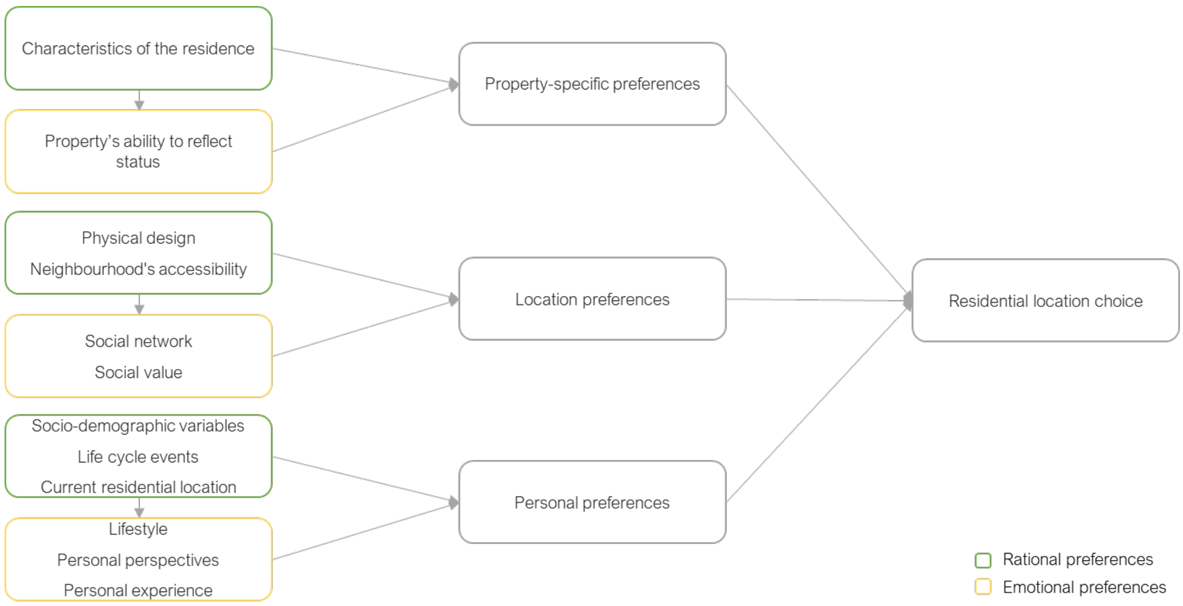

Figure 3.1: Conceptual framework of residential location choice

3.2 Residential location choice for car restricted residential areas

The conceptual framework presented in Figure 3.1 is used to structure literature on people's preferences regarding car restricted residential areas. As the property-specific preferences do not contribute to providing an understanding about how people evaluate the specific residential environment of car restricted residential areas, only the location and personal preferences concerning car restricted residential areas will be highlighted. However, first, the background on car restricted residential areas will be provided to gain an understanding of the specific characters of car restricted residential areas, before highlighting the location-specific preferences and personal preferences towards car restricted residential areas.

3.2.1 Background of car restricted residential areas

Crawford (2000) was first to theoretically construe a car-free city. He illustrated a car-free city as a city in which lifestyles and city aspects such as streets, public space, civil buildings, dwellings, passengers' transport and freight logistics are arranged to be people-centric and to enhance urban life rather than facilitating cars' functioning. In the following years, the term car-free (residential) area was broadly used in literature. The terminology is introduced to address the efforts of local governments to enhance the attractiveness of their city (areas) by setting restrictions for active and stationary cars (Melia, 2014). Contingent on the physical size of the restrictions, these areas can be referred to as 'car-free cities', 'car-free districts', 'or car-free zones' (Loo, 2018). However, in most cases, there are exceptions to the restricted access, since public vehicles such as emergency services or delivery vehicles are generally not denied access to these areas (Gundlach et al., 2018; Nieuwenhuijsen & Khreis, 2016).

Car-free residential areas could be areas in which cars have to be parked at the periphery of the settlement. On top of that, residents could be contractually bound not to own a car and alternatively are provided with car-sharing vehicles at the area's boundary (Coates, 2013; Melia, 2009; Ornetzeder et al., 2008). Alternatively, 'car-free' may refer to 'car-less', which indicates not adopting a car in the daily lifestyle, thereby being 'free' from the car (Brown, 2017). Contrarily, it is argued that since the introduction of cars, cars have become an essential part of present-day cities and many people's life. For this reason, the term 'car-free' can be used not to indicate residents living completely without owning or using cars, however just not parking at or near home. Nonetheless, for allowing this 'parking at distance' a 'city of short walks' should be provided, referring to a city where almost all services required by residents are within walking distance Minh (2016).

Currently, car restricted residential areas could be categorised into three categories (Morris, et al., 2009):

1. Visually car-free: access to motorised vehicles is restrained, but it is not sought to restrict or limit car ownership. Generally, parking is either established underground, in-building or at the periphery of the residential area.
2. Low-car: the overall parking standard is reduced.
3. Car-free: minor or no arrangements have been developed for vehicle infrastructure or residential parking.

Car restricted residential areas as an instrument

Around the world, municipalities reveal their increased interest in car restricted residential areas (Cathcart-Keays, 2015). Firstly, these settlements are established to reduce the attractiveness of car use, as these restrictions make car use more inconvenient and costly (Nobis, 2003; Ornetzeder et al., 2008; Scheurer, 2001). Conversely, restricting cars result in integrated transport systems becoming more convenient and thereby increasing the attractiveness of sustainable modes of transport (Ornetzeder et al., 2008). Subsequently, municipalities are aiming to revive the social function of streets (Clayden, McKoy, & Wild, 2006; Melia, 2009; Ornetzeder et al., 2008; Scheurer, 2001). Furthermore, a proposed result of introducing car-free residential areas is a reduction of environmental impacts of transport next to the aspiration to promote sustainable housing developments (Loo, 2018; Melia, 2014; Minh, 2016; Nieuwenhuijsen & Khreis, 2016; Ornetzeder et al., 2008). A final objective is to enhance city logistics, not only in terms of private package deliveries, likewise retail and supermarket provisioning and foodservice industry deliveries should be included as they correspondingly generate vehicle movements in these areas (Melia, 2014; El Din et al., 2013).

Current and planned applications of car restricted residential areas

As a result of the interest of municipalities in introducing car restricted residential areas. Throughout the world already various cases of car restricted residential areas exist. First, there are historic areas whose physical structure does not allow access to cars, areas which are not supplied by vehicle infrastructures such as islands, pedestrianised areas or newly developed car-free residential areas (Crawford, 2000). The development of city planning resulted in a policy shift that introduced the realisation of multiple car restricted residential areas (Jones, 2014; Newman & Kenworthy, 2015; Ortegon-Sanchez, Tyler, & Propan, 2016). Next to newly build neighbourhoods that were designed with a sustainable perspective or to create a nice and quiet neighbourhood, other initiatives were developed within a city's current physical structure, such as the superblocks of Poblenou in Barcelona (Chorherr, n.d.; GWL terrein Amsterdam, n.d.; Loo, 2018; Nieuwenhuijsen & Khreis, 2016; Ortegon-Sanchez et al., 2016; Peters, 2019; Rosenthal, 2009). Some of these applications restricted car parking or car ownership, whilst others implemented car-sharing systems, and some residents of these settlements even adopt a car-free lifestyle (Ortegon-Sanchez et al., 2016). Planned car restricted residential areas do focus on the same principles, by either establishing a walking-friendly city, enhancing the inhabitant's car independence or simply bounding cars to the edge of the neighbourhood (Adrian Smith + Gordon Gill Architecture, 2012; Toussiant, 2019). Also, within the Netherlands, multiple cities are considering or even already developing plans for car-free neighbourhoods. These initiatives vary in scale and are planned from Groningen to the Limburg. The Merwedekanaalzone in Utrecht will be the first newly developed car-free settlement in the Netherlands that will be designed with 1 parking space per 3 houses. This is unique for an area located within the city centre and might set the new standard for other cities within the Netherlands. Mobility on-demand services will facilitate the mobility needs of residents that do not own a private car (Gemeente Utrecht, 2020).

Characteristics

Most designs of car restricted residential areas are characterised by car parking facilities at the periphery and additionally various public transport stops. Furthermore, daily and non-daily facilities such as retail and food facilities are located within the residential area. The years of establishment of the most known car restricted residential areas vary between 1982 and 2006. Also, the number of occupants deviates between 1800 and 33500 people. Accordingly, their surface varies between 0,06 to 7,02 square kilometres. Even though the distance to the city centre seems to be an important factor in the attractiveness of a car restricted residential areas, not all residential areas seem to be located near the city centre and are even found at a distance of more than 10 kilometres from the city centre. Appendix C can be consulted for an extended overview, description and drafted visualisations of the design specific characteristics of current and planned applications of car restricted residential area.

3.2.2 Location preferences regarding car restricted residential areas

Rational preferences: Physical design and neighbourhood accessibility

One of the most distinctive aspects of car restricted residential area is the constraint regarding vehicular access. Hence, **parking arrangements** have to be set for people using cars (Loo, 2018). Vehicular access should be controlled and the consequence of adjacent neighbourhoods being overflowed by parked cars of people living in the car restricted settlement should be overseen (Antonson et al., 2017; Melia, 2009; Scheurer, 2001). Furthermore, the **proximity** and **security** of the **parking facilities** should be considered, as people are less likely to purchase a residence when the parking provided is not satisfying their needs (Stubbs, 2002). It has been found that people fear car vandalism when parking remotely, therefore parking facilities on the periphery should be provided of proper security to compensate for having to park from home (Balcome & York, 1993; Borgers et al., 2008). Considering the willingness to park remotely, de Groote et al. (2015) have found that (higher) **prices for car parking** would increase the willingness to park a car at distance or even discard a car.

Since car owners may be hesitant about the car restrictions, it is essential that the **physical design** of a car restricted residential area is **attractive**. In this case, car owners' drive to change is essential for the application of novelties and radical behavioural change (Banister, 2008; Nieuwenhuijsen & Khreis, 2016). For this reason, other aspects should be emphasised that allow residents to **fulfil** their **needs** despite the neighbourhood's car restrictions (Loo, 2018). Hence, it is argued that in car restricted residential areas space which was normally used for car infrastructure should be assigned to the establishment of **recreational areas** (Loo & Chow, 2006). Dedicating streets to recreational areas would improve the incentive to move to a car restricted settlement (Gundlach et al., 2018). This will not only make the area more attractive but most importantly will increase the acceptance of the car restrictions by the public, thereby making the incentive to move to the area more feasible (Nieuwenhuijsen & Khreis, 2016).

Rydingen et al. (2017) state that developing a residential area completely free of vehicles is not feasible. This is due to residences still requiring to be **accessible** to people with disabilities and vehicles delivering heavy goods, which in the end constitutes to traffic as well (Rydningen et al., 2017). Especially when a low level of car use is supported **access to public transport** needs to be facilitated (Borgers et al., 2008; Gundlach et al., 2018; Loo, 2018; Melia, 2009; Scheurer, 2001; Topp & Pharoah, 1994). Additionally, it may be essential to substitute vehicle infrastructure with **walking and cyclist infrastructure** to increase the willingness to live in a car restricted residential area (Gundlach et al., 2018). To support a residential area with fewer traffic movements, it is argued that the residential area should be designed **pedestrian-friendly** (Loo & Chow, 2006; Minh, 2016). Therefore, the settlement should reflect residents' needs such as **work, education, daily- and social needs** (Loo, 2018). Preferably, the area should be designed as a fine grid area serving diverse purposes and offering multiple services (Carse et al., 2013; Cervero & Radisch, 1996; Jacobs, 1993; Schwanen & Mokhtarian, 2005a). Accordingly, Melia (2014) observed that within car-free residential areas the **quality and accessibility of offered services** such as public transport or education-, sports- and shopping facilities are more enhanced. Next to the quality of offered facilities and services, the **quality of the built**

environment and urban planning in these areas appear to be high and contributing to the overall quality of life of its residents (El Din et al., 2013).

3.2.3 Personal preferences

Rational preferences: Socio-demographic variables

Borges and Goldner (2015) note that people younger than 65 years old and households with children are more likely to live in a car restricted residential area. The last is supported by the observation of Scheurer (2001), noting that on average occupants of residential areas are part of larger household sizes.

Emotional preferences: Lifestyle, personal perspectives and experiences

Another important finding is that people living in a car restricted residential area employ a different **travel behaviour** compared to people living in a conventional residential areas, as multiple studies determined that car restrictions resulted in lower **car use** and **car ownership** of residents (Melia, 2014; Nobis, 2003; Scheurer, 2001). This is supported by the opposite observation by Guo (2013a), concluding that the supply of parking facilities does influence the car ownership of households. The study found that residents that are offered car parking close to their homes possess more cars, employ more car trips and drive longer distances. Likewise, Nobis (2003) observed that 81 per cent of households living in the car restricted residential area of Vauban (Freiburg, Germany) previously possessed a car, from which two-third sold their car after moving there. Scheurer (2001) noticed a comparable car ownership reduction in the car-free residential areas of GWL (Amsterdam) and Florisdorf (Vienna) from respectively 10 and 62 per cent. Ornetzeder et al. (2008) discovered that 41 per cent of the people living in Florisdorf used the **bicycle** more often than before. Nonetheless, concluded that the decrease in car use was not the effect of moving to a car-free residential area since many residents stated to already have decided to sell the car before moving to the car-free settlement.

Scheurer (2001) found that the **car-free character** of the neighbourhood was just in some cases a decisive factor. Likewise, Ornetzeder et al. (2008) found that only 23 per cent of residents living in Florisdorf moved there because of the car-free character of the settlement. Yet 73 per cent of the respondents stated that the **green** and **healthy environment** was the rationale for moving there, as due to car restrictions, these areas are less exposed to greenhouse gas emissions, air pollution, noise nuisance and ‘urban heat islands’ (Loo, 2018; Melia, 2014; Minh, 2016; Nieuwenhuijsen & Khreis, 2016). Nevertheless, it is argued that this rationale may in both studies be correlated with the overall **pro-environmental** behaviour of the respondents. This is supported by the study of Loo (2018) that concludes that people’s **social and environmental values** were underlying the motivation to move to a car restricted area. Ortnetzeder et al. (2008) have found that households that live in a car restricted residential area are more concerned about the environment and had a lower carbon footprint compared to households living in a conventional residential area. However, Loo (2018) observed that not all people with these social and environmental values prefer to live in a car restricted residential area, as they hold different business, educational, daily or social needs (see subsection 2.1.6). Subsequently, Nieuwenhuijsen and Khreis (2016) noted people living in car-free residential areas engage in a more **active lifestyle**, since their lives are less engaged with car use. Moreover, restricting (private) vehicles directly results in less traffic, which has been indicated by Loo (2018) and Minh (2016) to reduce the risk and accordingly the number of road accidents, resulting in, in terms of traffic, a more **safe living environment**.

On the social aspect, introducing car restricted areas were found by Ornetzeder et al. (2008) to consequent in more **social cohesion** and social contacts, as residents were observed to be **more willing to help each other**. Ornetzeder et al. (2008) examined that residents living in the car restricted residential area of Florisdorf in Vienna were found to have made **more friends within the settlement** in comparison to conventional residences, and additionally stated that they knew more people by sight. However, Melia (2009) argued that social cohesion among residents could be the consequence of the stakeholder conclusion during the development of the car restricted residential area. Furthermore, Scheurer (2001) concluded from the household sizes living in a car restricted residential area, that these offer a **good environment for children**. Which is supported by the observation of Nuetzel (1993) and Clayden et al. (2006) that contrarily to conventional streets, children living in home zones (woonerf) could play outside without direct parental supervision at a younger age. In a later study, Melia (2014) supported these conclusions by stating car restricted residential areas to enhance social interaction among residents, reduces the risk and fear of road accidents and provides more independence for children.

3.3 Willingness to move to a car restricted residential areas

Previous studies show that the incentive to relocate in a certain settlement is driven by property-specific, location and personal preferences. For car restricted residential areas only the location and personal preferences are essential in determining the preference for moving to a car restricted residential area. Accordingly, the physical design of the residential area, people's socio-demographic characteristics, travel behaviour and attitudes towards travel modes, residential environment and environment are found to be essential aspects of determining the preferences for living in a car restricted residential area.

Additionally, three studies observed the willingness to live in a car restricted residential area. Borges & Goldner (2015) determined the influence of socio-demographic characteristics on the willingness of people to move to a car restricted residential area. Through logistic regression analysis, they have found that residents of Floriapolis (Brazil) using sustainable modes of transportation, people younger than 65 years old and households with children are more likely to live in a car restricted residential area. Gundlach et al. (2018) studied the trade-off between the design of alternative transport modes and living in a car restricted residential area. Their study found that given the current infrastructure in Berlin (Germany) 60% of their respondents, of which 80% were students, were willing to move to a car restricted residential area. Moreover, they found that improvements to bicycle infrastructure and the network of bus stops and train stations, next to assigning public space to recreational uses would enhance the likelihood of people moving to a car restricted residential area. Nonetheless, only 20% of their sample did own a car, and people owning a car seemed not likely to move to a car restricted residential area. Lastly, Borgers et al. (2008) researched the trade-off between parking at distance and the design of infrastructure in the car restricted residential area. Their study concluded that most people do not prefer to live in a car restricted residential area, however remote car parking in these residential areas can be partly compensated by providing secured parking facilities, good non-motorised transport facilities and access to public transport at a short distance from residences.

Considering the attractiveness of the design of a car restricted residential area, as elaborated in Section 3.2.2, current literature indicates that the design of the neighbourhood should consider three aspects. First, it is noted that as cars are restricted from the residential area, the accessibility of the settlement should be maintained, preferably by enhancing public transport, walking and cycling infrastructure. Secondly, the design of parking facilities should be considered, as the vehicular restrictions involve car owners to park their cars in designated places. Lastly, the physical design of the residential environment should be enhanced to compensate for remote parking.

Although these studies provide valuable insights, there is limited research concerning the preference for living in a car restricted residential area resulting from the design of car parking and the design of the physical environment of the settlement. It is unknown how people trade-off the design of car parking to the design of the physical environment of a car restricted residential area. This information is relevant for policymakers, urban developers, and project developers, as currently there is no knowledge of the preference of Dutch car owners for a car restricted residential area in relation to these variables. Establishing neighbourhoods with low parking levels and expensive parking facilities is perceived as a risk, as uncertainty exists about the willingness of car owners to move to these areas and the risk of these costly parking facilities being left unused. Therefore, understanding of the extent to which design variables of car restricted residential areas affect the willingness to move to these areas would be relevant for considering different designs of car restricted residential areas.

3.4 Implications for research demarcation

The insights gained by the literature review will be reflected in the demarcation of the research. The research scope will be described in terms of the type of residential area that will be considered, the selection of the degree of car restrictions, the geographical location, and lastly the examined sample.

3.4.1 Newly build residential areas

The first demarcation is the type of residential area that will be examined, in this case, new housing development over an existing development. Since newly build residential areas within cities require a compact design of residences in order to utilize inner-urban available areas as efficient as possible while reducing the housing shortage. Besides that, the concept of a car restricted residential area is currently unfamiliar to people. Therefore, it could be challenging for people to imagine their neighbourhood without cars. Hence, focussing on new housing development may be more fitted as in general people move to a new residence because of the residence, neighbourhood or life-stage related preferences that no longer suit their needs or preferences. Therefore, people looking for a new residence may be more open-minded to major changes in urban design in these kinds of areas than introducing car restrictions in their current residential environment (Jiang et al., 2019). This assumption is supported by the findings of Borges and Golder (2015) concluding that in a country where there is no example of a car restricted neighbourhood, it may be more feasible to introduce major adjustments in the design of a residential area when constructing a residential area rather than restricting vehicles in a residential area that already exists.

3.4.2 Visually car-free residential areas

Secondly, the degree of car restrictions operationalised in this research is selected. This research will take into account that vehicles nowadays are an integral part of modern cities and therefore apply the perspective of Minh (2016) where the term 'car-free residential area' does not indicate that residents do not own or use a car, however, park their car remote from their residence. Hence, the research will focus on a car restricted residential area that is visually car-free indicating that vehicles are parked underground, in-building or at the periphery of the neighbourhood, however, car ownership is not restricted. Thus in the residential areas considered in this research vehicles will not determine the street scenery. This means that cars will not be parked in or drive through streets and are allowed on an exceptional basis.

3.4.3 Residential areas in the Netherlands

Furthermore, the research will be demarcated in a geographical location. Since every country is characterised by possessing different living- and transportation preferences and customs it is chosen to delimit the study to the Netherlands. Although the housing shortage is highest the four cities in the Netherlands with the highest population; Amsterdam, Rotterdam, Utrecht and The Hague, and therefore the motivation for innovative changes is strongest there, no further geographical demarcation is set for the reason to be able to provide suggestions for various living environments throughout the Netherlands (G4, G40 cities and other).

3.4.4 The preference for moving to a car restricted residential area over a conventional residential area

The fourth choice was to include a base alternative to the proposed alternatives that will require respondents to express their preference between moving to a car restricted residential area and a conventional residential area. In this way, the willingness to move to a car restricted residential area compared to a conventional residential area can be determined.

3.4.5 Preference of car owners

A fifth demarcation contemplates the research sample. The research will focus on car owners since the trade-off between the distance of the car parking facilities and the physical environment of the residential area can only be made by car owners. Therefore, the effect of the design of these residential areas on the willingness to move to a car restricted residential area for people that do not own a car is ignored.

3.5 Conclusion

The method used in this research to study the willingness of car owners to move to a car restricted residential area is discrete choice analysis. The theory underlying this method assumes that people choose to reside in a living environment that maximises their utility. Although, this theory assumes that people are rational decision-makers, also irrational (emotional) preferences will be included in the review as they may be based on objective variables that can be measured and included in the model as well.

Previous studies observed people's preferences for living in a car restricted residential area depending on the provided replacing infrastructure in these areas, or observed which groups of people would be interested in moving to a car restricted residential area. Furthermore, the preference for living in a car restricted residential area is influenced by the physical design and neighbourhood accessibility (rational location preferences), socio-demographic variables and current residential location (rational personal preferences) and lifestyle and personal perspectives and experiences (emotional personal preferences).

4

Survey design and data collection

The insights on the variables influencing car owners' willingness to move to a car restricted residential area are used to establish the survey. First, the stated preference experimental design is established, including a selection of the variables that are most important to car owners and used to characterise the residential area alternatives presented to the respondents via the survey (Section 4.1). Furthermore, the statements are drafted that are used to measure latent attitudes that may influence car owners' willingness to move to a car restricted residential area (Section 4.2). The choice experiment and the statements will only form two parts of the survey and the total outline of the survey and its construction is provided in Section 4.3. The survey will be dispersed among car owners, the specific survey distribution method and the sample are described in Section 4.4. The chapter concludes with an overview of the survey design process (Section 4.5)

4.1 Stated preference experimental design

In the stated choice experiment, respondents are presented with two residential area alternatives. These alternatives will consist of several characteristics (attributes) that will be varied over multiple levels (attribute levels). The consolidation of these levels comprises a choice profile and the combination of two alternatives a choice set which is accompanied by a choice task.

4.1.1 Selection of attributes

To assess the willingness to move to car restricted residential areas, the influence of several residential area characteristics will be researched. Although it is attractive to include a high number of characteristics that could be researched, including a high number of attributes may lead to difficult choice tasks. Therefore, a selection of design variables included in the model should be made. However, a disadvantage of applying stated preference surveys is that designing these experiments may involve bias from the researcher, as the researcher determines the important attributes (variables) that are incorporated in the design and controls which alternatives are provided (Molin & Timmermans, 2010). Therefore, it is important to include the attributes that respondents find important in the selection of attributes, next to the attributes that are relevant for designing car restricted residential areas (variables that can be influenced by policymakers or the project developers). To overcome this researcher's bias in designing the experiment, the insights gained by the review of the literature will be used as input for creating the survey. This information allows making a substantiated selection of variables that are included in the choice model. The following attributes are selected for this study:

- Walking time to the car
- Type of car parking facility
- Monthly car parking costs
- Type of building in the residential area
- The liveliness level in the residential area
- Facilities the residential area
- Green facility level in the residential area

The first three attributes regard car parking because in general car restricted residential areas are accompanied by restricted vehicular access and therefore car parking should be well designed. In most cases, it is not possible to park a car near home, therefore the first attribute covers the walking distance to the car. However, since distances, in general, are difficult to perceive, the distance is adjusted to walking time to the car. On the matter of remote car parking, the type of car parking facility is found to be especially important to residents (Balcome & York, 1993; Borgers et al., 2008). Lastly, parking prices relate to the willingness to park remotely (de Groote et al., 2015). Furthermore, including a cost aspect will allow determining the willingness to pay for the design attributes of the car restricted residential area.

Moreover, four physical design aspects are selected, as these influence the incentive to move to a certain residential area (Jarass & Scheiner, 2018; McCormack et al., 2019; Tu & Eppli, 1999). With regard to a car restricted residential area, the building environment and liveliness level have been found as important determinants of their attractiveness (Carse et al., 2013; Cervero & Radisch, 1996; Jacobs, 1993; Schwanen & Mokhtarian, 2005a). Furthermore, as the neighbourhood allows less vehicular traffic, most trips to facilities should be carried out by foot. For this reason, a car restricted residential area should consist of all the facilities that reflect its residents' needs (Loo, 2018). Lastly, it is argued that space normally used for vehicle infrastructure should be assigned to green areas, in fact, people generally prefer the green aspect of car restricted residential areas (Gundlach et al., 2018; Loo & Chow, 2006; Nieuwenhuijsen & Khreis, 2016).

4.1.2 Selection of attribute levels

Each neighbourhood aspect will be varied in multiple levels. All attributes will have three levels, which are indicated in Table 4.1.

Table 4.1: Attribute levels of the choice experiment

Attribute	*Attribute levels*
Walking time to the car parking facility	*0,5 minutes*
	5 minutes
	9 minutes
Type of car parking facility	*Private parking space in a parking garage*
	Public parking garage
	Public parking lot
Monthly parking costs	*€ 0,-*
	€ 150,-
	€ 300,-
Type of building in the residential area	*Mainly* high-rise *building*
	Mainly low-rise building
	Mixed high and low-rise
The liveliness level in the residential area	*Hardly people on the street*
	Lively street scene with residents
	Lively street scene with residents and trespassers
Facilities in the residential area	*Only a supermarket*
	A simple range of facilities
	A broad range of facilities
Green facility level in the residential area	*Small parks spread throughout the neighbourhood*
	One big central park
	Streets with wide grass strips and trees throughout the neighbourhood

The levels for walking time to the car parking facility is based on the walking distances of 50 metres, resembling parking near your house, 400 metres for parking in a car parking in the street and 750 metres for car parking at the periphery of the residential area. The walking time is computed with an average walking speed of 5 kilometres per hour. The type of car parking is varied between the combinations of having a private parking space or making use of public parking and indoor versus outdoor parking. The monthly parking costs are deduced from the subscription costs of parking in a public parking garage in Dutch cities (Gemeente Amsterdam, n.d.; Gemeente Den Haag, n.d.;

Gemeente Rotterdam, n.d.; Gemeente Utrecht, n.d.; Planbureau voor de Leefomgeving, 2008; Waard, 2020).

The type of building in the residential area is composed of mainly high-rise building, low-rise building or a mixture of both. Furthermore, the liveliness levels that are selected are derived from the liveliness levels in several types of neighbourhoods. A residential area in or near the centre of a city is characterised by having a lively street scene with not only residents but also trespassers. Other residential areas are portrayed with children playing on the streets or people sitting in the front of their houses, and in (as the name indicates) sleeping neighbourhoods hardly anyone can be found on the streets. The levels of facilities that can be found in the residential area are characterised in the same way. In city centres, a broad range of facilities can be found, whilst some neighbourhoods have a neighbourhood centre in which a bakery, flower shop or butcher additional to a supermarket can be found and lastly suburbs often only contain a supermarket. Lastly, the green facilities come in three levels as well, one in which small parks are spread throughout the neighbourhood, one consisting of one big central park, such as in most cities and one in which the streets are portrayed with wide grass strips and trees throughout the neighbourhood, which sometimes can be found in fringe areas.

4.1.3 Construction of profiles

Several combinations of attributes are used to construct choice profiles. A full-factorial design will provide all possible combinations of the attribute levels. However, this will result in a large number of alternatives, and (too) many choice sets for the respondents to properly evaluate. Accordingly, to reduce the number of alternatives a fractional factorial design is used. Three types of fractional factorial designs are distinguished: a random design, an orthogonal design and an efficient design. A random design randomly selects a fraction of the full factorial design. Nevertheless, this leads to a correlation between attributes, resulting in higher standard errors of parameter estimates, and thus less reliable parameters. In an orthogonal design, each level is represented equal times in the choice sets and therefore attribute levels are uncorrelated. However, in an orthogonal design, dominant alternatives can occur. A dominant alternative is an alternative that performs better than the other alternatives in the set. The likelihood of respondents choosing that specific alternative of the set of alternatives is very high. A choice set containing a dominant alternative, therefore, does not provide any information about people's trade-offs and therefore may result in biased parameter estimates in the model estimation (Huber et al., 1982). However, the third type of fractional design allows avoiding alternative dominance by balancing utility between alternatives. Thereby the design may decrease the standard errors and increase the reliability of parameter estimates. Furthermore, an efficient design may reduce the number of choice sets that should be included in the choice experiment. Furthermore, an efficient design allows determining the required number of respondents to obtain a reliable outcome. For this reason, an efficient design is used for drafting the stated choice experiment. Yet, determining an efficient design requires priors. For that reason, a prior survey is dispersed. The prior study is drafted based on an orthogonal design. The parameter estimates resulting from this survey are used as priors for determining the efficient design of the final choice experiment. The efficient design is determined with the software programme Ngene and resulted in 18 choice sets (ChoiceMetrics, 2018). The experimental design obtained by Ngene is presented in Appendix D. As the choice experiment requires a lot of effort for respondents and the questionnaire consist of additional questions regarding car use, current residential environment, respondent characteristics, and statements, the choice sets are allocated over three blocks. This means that the choice sets were distributed over three versions of the survey, so each respondent is presented with six choice tasks.

4.1.4 Construction choice sets

It was chosen to include two alternatives per choice set, as this reduces the choice effort for respondents. So, respondents are asked to choose between two residential area alternatives that both consist of the same attributes and attribute levels. The alternatives, therefore, are called unlabelled, and the choice sets are sequential constructed (ChoiceMetrics, 2018). The first interest of this research is determining the willingness of car owners to move to a car restricted residential area. Furthermore, the trade-off between several design variables is scrutinized. When only providing respondents with the choice between the two residential areas, more information is obtained about the trade-off among attributes. However, this reveals no information about the willingness to move to a car restricted residential area as there is no observation of the choice between a car restricted residential area and a conventional residential area. For this reason, the choice sets are supplemented with a third alternative, the base alternative.

4.1.5 Choice task

There are two options to include the base alternative to the choice sets. First, the base alternative is included as the third choice option. However, a disadvantage is that there exists a possibility that a large part of the sample will immediately choose the conventional residential area over the two car restricted residential areas, which is plausible since car restricted residential areas are unfamiliar. Therefore, the second option is to first present the respondent with the choice between two car restricted residential areas. Thereafter in a second question, the respondent is presented with the choice between the selected residential area and a conventional residential area. The advantage of the last option is that in case a large part of the sample chooses the conventional residential area, the choice data of the two car restricted residential areas can still be used to gain insight into the trade-off between design variables. The question is asked as if someone is in the process of moving to a new residence and considering several residential area alternatives. Therefore, the two questions that will be asked to the respondent after presenting each choice set are:

1. Which car restricted residential area do you prefer to live in?
2. If you have to move within 6 months, would you move to the selected car restricted residential area?

An example of a choice task is provided in Figure 4.1

		Residential area 1	**Residential area 2**
Car parking	**Number of minutes from your residence to the car**	9	0,5
	Type of parking facility	*Private parking space in a parking garage*	*Public parking lot*
	Monthly parking costs	€150	€0
Residential area 	**Type of building in the residential area**	Mainly low-rise building	Mixed high and low-rise
	Liveliness level in the residential area	Lively street scene with residents and trespassers	Hardly people on the streets
	Facilities in the residential area	Only a supermarket	A broad range of facilities
	Green areas in the residential area	*Small parks spread throughout the neighbourhood*	*Streets with wide grass strips and trees throughout the neighbourhood*

Which car restricted residential area do you prefer to live in?

○ Residential area 1
○ Residential area 2

If you have to move within 6 months, would you move to the selected car restricted residential area?

○ Yes, I would move to the selected car restricted residential area
○ No, I would prefer to live in a non-car restricted residential area

Figure 4.1: Example of a choice task

4.1.6 Choice modelling

The choices will be modelled, according to a utility function. The systematic utility function is specified in Equation 4.1. Since the car restricted residential area alternatives are unlabeled, this function is identical for both alternatives.

$$V_i = \beta_{CRRA} + \beta_{PWT} * PWT + \beta_{PT} * PT + \beta_{PP} * PP + \beta_{BT} * BT + \beta_L * L + \beta_F * F + \beta_G * G \quad (4.1)$$

In which:

- V_i = utility of alternative i
- β_{CRRA} = alternative specific constant for car restricted residential area
- β_{PWT} = parameter for the variable 'Walking time to the car' (PWT)
- β_{PT} = parameter for the variable 'Type of car parking facility' (PT)
- β_{PP} = parameter for the variable 'Monthly car parking costs' (PP)
- β_{BT} = parameter for the variable 'Type of building in the residential area' (BT)
- β_L = parameter for the variable 'The liveliness level in the residential area' (L)
- β_F = parameter for the variable 'Facilities in the residential area' (F)
- β_G = parameter for the variable 'Green facility level in the residential area' (G)

4.2 Attitude measurement design

To understand the underlying perceptions of car owners towards car restricted residential areas, the survey was supplemented with several statements that enable measuring these perceptions. For the selection of statements, literature is consulted.

To limit the survey's length a trade-off had to be made for the number of statements that were included. First, a selection of attitudes was made, furthermore, some attitudes are only measured by one statement. The operationalisation of the attitudes and the statements included in the questionnaire are presented in Table 4.2.

Table 4.2: Operationalisation of attitudes on car restricted residential areas

Statement	Attitude	Source
1. A car gives me the feeling of freedom.	Perceived car freedom	(De Vos & Alemi, 2020; Kitamura et al., 1997)
2. Without a car, I would feel very limited in what I can still do.	Perceived car freedom	(Cao et al., 2007; Handy, 2004)
3. I need my car to do all of my activities properly.	Perceived car dependency	(Cao et al., 2007; Handy, 2004)
4. I think travelling by car should be flexible.	Perceived car flexibility	(Cao et al., 2007; Handy, 2004)
5. I think I could live with a car less or without a car.	Perceived car dependency	(Cao et al., 2007; Handy, 2004)
6. I find going to work without a car a hassle.	Perceived car flexibility	(Cao et al., 2007; Handy, 2004)
7. I consider the nearest parking space to my house as my own parking space.	The perceived value of car parking	(Totta Research N.V., 2018)
8. I prefer to park my car in front of my house.	The perceived value of car parking	(Totta Research N.V., 2018)
9. I drive extra laps until a parking space becomes available that is closer to my house.	Perceived parking hassle	(Totta Research N.V., 2018)
10. I believe that having a car parking space near my home increases my home value.	The perceived value of car parking	(Totta Research N.V., 2018)
11. I prefer to park my car as close to my house as possible when I have groceries with me.	Perceived parking hassle	(Totta Research N.V., 2018)
12. I think it is important that shops and services are within walking distance of my home.	Pedestrian supportive	(Handy, 2004; Mokhtarian et al., 2001)
13. I think my living environment should be pedestrian-friendly	Pedestrian supportive	(De Vos & Alemi, 2020; Ettema & Nieuwenhuis, 2017; Handy, 2004)
14. I think it is important that children have a place in their living environment where they can play safely	Child friendly	(Handy, 2004; Kitamura et al., 1997)
15. I like to live in a green environment.	Healthy environment	(Handy, 2004)
16. I like to live in a quiet environment.	Healthy environment	(Handy, 2004)
17. I think it is important that I have contact with my neighbours.	Community-focused	(Handy, 2004)
18. I enjoy living in an environment where there are always people on the street.	Community-focused	(Mokhtarian et al., 2001)
19. I believe that high-density housing development should be encouraged.	Urban ambition	(Kitamura et al., 1997)
20. I believe that a residential environment should be car-free.	Pro car-free	(De Vos & Alemi, 2020; Handy, 2004)
21. I think cars pollute the street scene.	Pro car-free	(De Vos & Alemi, 2020; Handy, 2004)

4.3 Survey construction

In addition to the stated choice experiment, the survey will be supplemented by a questionnaire with questions and statements. These questions and statements allow determining the influence of socio-demographic variables, car use (before COVID-19), current residential environment and attitudes towards car use and a car restricted living environment. The questionnaire was constructed with the software Qualitrics (Qualitrics, 2020). A brief description of the questionnaire is provided, the full questionnaire is outlined in the Appendix E.

4.3.1 Survey outline

Introduction

First, an introduction to the questionnaire is provided. This introduction aims to inform respondents on the objective of the survey and to stimulate them to fill in the survey. The introductory text is signed with the researcher's name to make the request personal. Furthermore, contact details are provided in case a respondent has questions.

Questions about car use and current residential area
Thereafter, the survey starts with questions about car use and respondents' current residential environment. Since these questions are relatively easy to answer, these questions serve as a warming up for the choice experiment.

Choice experiment
After the warming up questions, the respondents are presented with the introduction to the choice experiment. In the introduction, an explanation of the choice experiment is provided, and additionally, an example of a choice task is included to familiarise people with the choice tasks. This is followed by a description of the attributes before the actual choice experiment.

Attitudinal statements
After the choice experiment, the respondent is presented with some statements about car use, living environment and their expectations of a car residential environment in terms of traffic safety, traffic nuisance, traffic amount, availability of parking, accessibility of parking, presence of walking paths, bicycle infrastructure and green areas.

General questions
The survey finishes with general questions to gain knowledge of the respondents' socio-demographic characteristics. This information is required to describe the sample and to assess whether the sample is representative of the population.

Expression of gratitude
Lastly, the respondents are presented with a text expressing the researcher's gratitude. Furthermore, a text box is included that could be used to leave questions or remarks, and a text box is included in which respondents could fill in their e-mail address if they were interested in participating in the lottery of the voucher.

4.3.2 Pilot survey and survey enhancements

Before the actual survey, a pilot survey was distributed among friends and family and colleagues. The aim of distributing the pilot survey was to collect feedback and improve the survey. Furthermore, the pilot survey was used to estimate priors in order to generate a more efficient design free of dominant alternatives. The prior survey was completed by 32 respondents. People were requested to go complete the survey and reflect on whether all the questions and information that was presented was clear to them and to suggest points of improvement.

First, it was checked what the average time was to fill in the survey and if this was corresponding with the time indicated in the introduction of the survey. Moreover, respondents pointed out that in many choice tasks it was easy to choose an alternative since there were some dominant alternatives in the choice sets. However, one of the aims of the study was to improve the design of the choice experiment. On the other hand, it was indicated that the choice tasks were very hard and intensive. For this reason, it was chosen to reduce the number of choice tasks to six per respondent. Furthermore, it was indicated that the description of the attributes was, in some cases, not clear enough. Although it is not preferred to include long texts for this description, in the final survey a logical description of the attributes was provided. Lastly, some changes were made in the structure of sentences, questions, and answers.

4.4 Survey distribution

4.4.1 Population and sample

The population of this research is car owners living in the Netherlands. However, it was chosen not to restrict the sample beforehand to people in possession of a car, as there was uncertainty about the number of respondents that would fill in the survey. Therefore, the survey was adapted to also include people not owning a car. This regains the flexibility of adapting the objective of the study in case of a lack of respondents. The objective could then be changed to the overall preferences towards a car restricted residential area. In case sufficient data will be collected, the people not owning a car can be removed from the data set. The efficient design created by Ngene (ChoiceMetrics, 2018) is used to determine the minimum number of respondents that is required. This design reports the S-estimate value, expressing the required number of respondents to obtain statistically significant parameter estimates at the 95% confidence level. The reported S-estimate value indicated that the minimum required sample size is 64.

4.4.2 Survey distribution method

The survey was distributed on social media and through pamphlets that were dispersed in mailboxes. This method of approaching respondents was due to the restrictions on physical contact between people. Accordingly, 5000 pamphlets were spread in multiple neighbourhoods in three cities and two towns: Hilversum, Kortenhoef, Pijnacker, Rotterdam and The Hague. This selection was made to obtain a mix of residential areas and residential environments and to make sure to include respondents of different segments and with different views on car restricted residential areas. An illustration of the mailbox pamphlets is provided in Figure 4.2.

Figure 4.2: Mailbox pamphlets

3.5 Conclusion

Seven variables affecting the willingness to move to a car restricted residential area are selected to study their influence on the willingness to move to a car restricted residential area: (1) walking time to the car, (2) type of car parking facility, (3) monthly parking costs, (4) type of building, (5) liveliness level, (6) amount of facilities, and (7) the degree of green areas. Accordingly, via a survey respondents will be requested to indicate their preference for designs of car restricted residential areas and if they would consider moving to the residential area of their preference over a conventional residential area. The survey furthermore will be supplemented by statements measuring attitudes towards car use and (car restricted) residential environment, questions regarding car use, current residential environment and lastly socio-demographic variables.

5

Descriptive statistics

Respondents' answers to the questions are collected, reviewed and analysed to gain an overview of the sample that is been studied and to determine possible implications for estimating the discrete choice models. The data collection method and evaluation process are described accordingly possible implications for the model estimations that are noted are discussed (Section 5.1 and Section 5.2). Furthermore, the characteristics of the sample are evaluated by which its representativeness for the population is determined (Section 5.3). Moreover, the sample's characteristics regarding socio-demographic variables, car use, current residential environment and attitudes are outlined (Section 5.4) Lastly, the insights gained from the sample's characteristics and the potential consequences to the model estimation and interpretation are provided (Section 5.5).

5.1 Data collection

The data is collected in the period between May 25 and June 10, 2020. In total, the questionnaire reached 6347 people from which 501 opened the survey and 330 finished the survey. The **drop out range**, therefore, was equal to **34,2%**. Furthermore, people took on average 24 minutes and 10 seconds to finish the questionnaire.

However, it should be stated that the data collection method introduces the **possibility of selective bias**. Firstly, as questions are asked online and through mailbox pamphlets, self-selection is occurring. It may be that people who oppose cars or highly value a car could be more inclined to fill in the survey to express their strong opinion about a car restricted residential area. Secondly, the lottery of the gift voucher may have caused that people did not take full effort to fill in the survey. However, these risks are encapsulated by assessing and cleaning the data.

5.2 Data cleaning

The **330 responses** were evaluated and cleaned to reduce the risk of the former described selective bias which may result in biased parameter estimates.

5.2.1 Evaluation of non-choice data

A first evaluation of the data resulted in the exclusion of 73 responses based on the following rationale:

- **10 respondents** completed the questionnaire in less than 8 minutes. This could be caused by the incentive provided to the respondents, risking respondents rushing through the survey just to have a chance at achieving the gift voucher. It was assumed that completing the survey reliably requires at least 8 minutes.
- **63 respondents** did not own a car and for this reason not forming an interest in this specific research.

5.2.2 Evaluation of choice data

Furthermore, the choice behaviour of respondents is analysed on the occurrence of dominant alternatives and non-trading behaviour of respondents.

Dominant alternatives

The distributions of the selected choice alternatives are used to determine if dominant alternatives occur in the choice tasks that should be removed before estimating the models. A dominant alternative is an alternative that performs better than any other alternative in the choice set for all the included attributes (Bliemer et al., 2017). Therefore, the probability of a respondent choosing that specific alternative is high and thus provides limited information about the trade-offs respondents make, resulting in biased parameter estimates (Hensher et al., 1988).

In each choice set, respondents were presented with two questions. In the first question, respondents were requested to indicate their preference between two displayed car restricted residential areas. In the second question respondents were asked whether, given the fact that they have to move within 6 months, they would move to the residential area which they selected in question 1 over a conventional residential area. Figure 5.1 and Figure 5.2 present the distributions of the choices that were made by respondents in respectively the first and second question.

Figure 5.1 indicates that choice set 1 in block 1 and choice set 2 in block 2 contain a dominant alternative. In the first choice set of block 1 around 90% of the respondents chose residential area two over residential area one. In the second choice task in block 2 more than 90% of respondents chose residential area one over residential area 2. This does have implications for the choice estimations as a dominant alternative provides little information about the trade-offs respondents make and even leads to significantly biased parameter estimates (Bliemer et al., 2017; Hensher et al., 1988). For this reason, choice tasks containing dominant alternatives should be removed from the dataset before estimating the model. For the estimation of the model with only two alternatives (see Appendix H) the two choice tasks containing a dominant alternative are removed from the dataset.

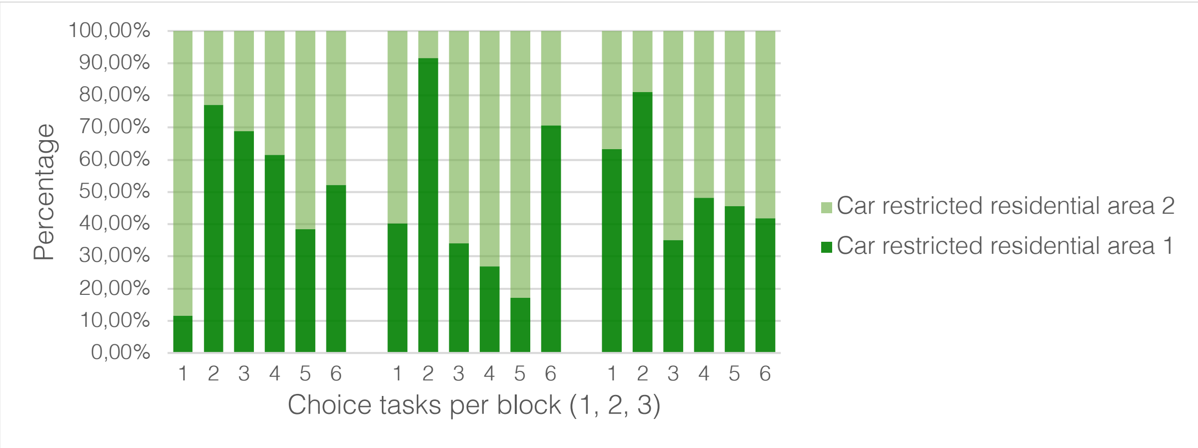

Figure 4.1: Distributions of the answers to the first question of every choice set

The second question includes the option of not moving to a car restricted residential area. Figure 5.2 displays the distribution of the alternatives that are selected by the respondents. On average 62,4% of the times respondents choose not to move to a car restricted residential area. In total 1542 choices were made, from which car restricted residential area one was chosen 304 times. Residential area two was selected 274 times and the decision not to move to a car restricted residential area was made 962 times. From Figure 5.2 it can be observed that the choice tasks of the second question do not contain dominant alternatives.

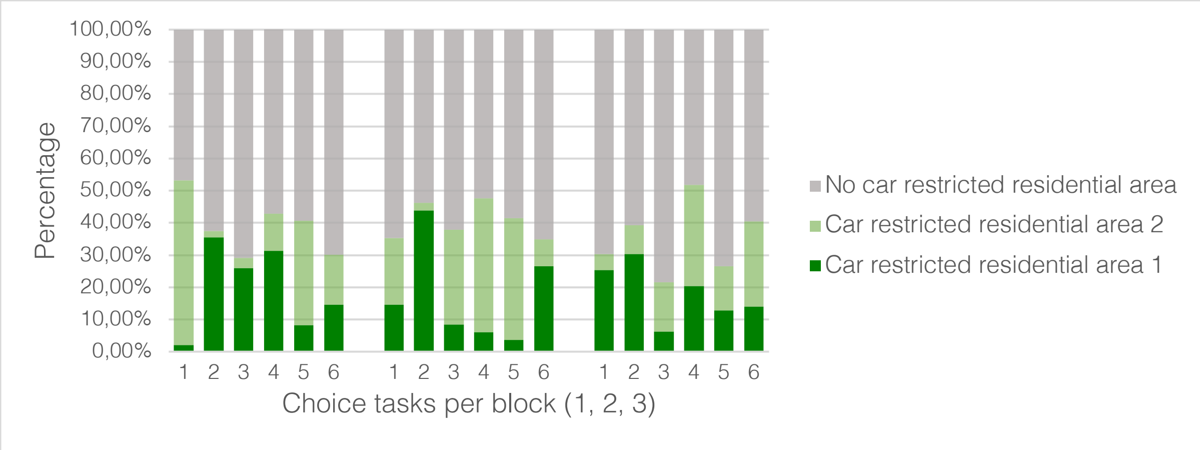

Figure 4.2: Distributions of the answers to the second question of every choice set

Non-trading behaviour

Secondly, the data is monitored on non-trading behaviour that could influence the model estimation as well. Non-trading behaviour refers to the situation where a respondent always selects the same alternative across the presented choice sets. This may be resulting from (1) people having an extreme preference for a specific alternative, (2) misunderstanding, boredom or fatigue during the stated preference experiment may be expressed in a constant decision-making behaviour, or (3) political or strategic behaviour. This non-trading behaviour, therefore, may lead to biased parameter estimates (Hess et al., 2010).

For as well question one as question two it was assessed whether there were people that chose the same alternative in each choice set. For question one, no non-trading behaviour was observed. However, in the second question, 6,4% of the respondents selected the same alternative in each choice set. Firstly this may indicate that some people have an extreme willingness to move to a car restricted residential area or a conventional residential area since 68,4% of the respondents always chose not to move to a car restricted residential area and the other 31,6% always chose to move to the selected car restricted residential area. Secondly, the unchanging choice behaviour may also be the result of misunderstanding, boredom or fatigue. Lastly, this behaviour may reflect political or strategic behaviour of people that do or do not support the development of car restricted residential areas.

In the case of non-trading behaviour of respondents resulting from non-utility maximising behaviour, these observations should be removed from the choice set, as these will provide no information about the trade-off. The effect of indifferences on the choice behaviour is tried to encapsulate by checking the completion time of the surveys. Non-trading behaviour resulting from utility maximising behaviour, such as an extreme preference for a specific alternative, should be included in the model. This behaviour will only affect the estimation of the alternative specific constant. Since the observed percentage of non-trading behaviour is fairly low, these observations are not removed from the dataset.

5.3 Representativeness of the sample

In order to assess whether the sample reflects the population properly, the contrast between the sample and the population is scrutinized, which in this case are car owners living in the Netherlands. Yet, as recent data of this target group is missing, the data of the total Dutch population is used as a proxy of the population numbers. The socio-demographic characteristics of gender, age, educational level, and household income level are used for the comparison of the sample and the population.

The sample shows resemblance to the population considering the gender distribution. However, the distribution of age, educational level and household income level deviate from the population distributions. Additionally, Chi-square tests are performed to statistically test the representativeness of the sample (See Appendix G for the assessments). Correspondingly to the first comparison, the Chi-square tests indicated that only gender does not significantly differ from the population. Therefore, the sample in this research may not be considered as representative of the population.

Nevertheless, the unrepresentativeness of the sample does not necessarily have consequences for estimating the choice models as they depend on correlations. This only means that results should be interpreted with care, since choice behaviour in the sample may be more severe than in the population. Furthermore, it should be assessed whether the unrepresentative socio-demographic variables are affecting the decision to move to a car restricted area. The estimated results originating in the sample's choice behaviour may be incorrect predictors for the choice behaviour in the population in case certain unrepresentative characteristics of the sample turn out to affect the choice behaviour.

5.4 Characteristics of the sample

The sample will be defined by socio-demographic characteristics, car use, current residential environment, and attitudes. The distributions of the sample will be provided, and if they were available, the distributions of the population are provided as well to indicate the deviations between the sample and the population on these characteristics. The data used to characterise the population were collected from CBS Stateline. The Dutch population numbers were substituted for the numbers for the population of this research.

5.4.1 Socio-demographic characteristics

Table 5.1 displays the sample distributions on the variables gender, age, education, household income, daily business, household compositions, number of kids per age class, and number of people in the household that are infirm or disabled. Considering gender, the sample is equally distributed. Yet, the number of respondents in the age level of '65 years and older' are underrepresented. This may impact the parameter estimations, as people of various ages may perceive car restricted residential areas differently. Likewise, the sample possesses a fairly high frequency of middle- and higher-level education and above-average household income. In terms of daily business and household compositions, the sample and the population are dissimilar. In the sample, the segment of people being employed is higher than the number of employed people in the population. The variation between the sample and the population in terms of age seem to affect the distribution of daily business in the sample. Since the segment of people older than 65 years is less than in the population this may clarify the lower contribution of people that are not working in the sample compared to the population. It could be that people's daily business affects how they perceive living in a car restricted residential area, and therefore the deviation from the population results in biased parameter estimates.

Furthermore, when comparing the distributions of household size in the population to the distributions in the sample deviate. The contribution of more person households in the population is lower compared to the contribution of more person households in the sample. Nevertheless, the mean household size does not differ much between the sample and the population. Considering the distribution of the number of children (younger than 18 years old) per age class in the household, the composition of age classes is equally distributed over the age classes. Furthermore, two-thirds of households have one child per age class category. Lastly, Table 5.1 displays that most households do not contain people that are infirm or disabled, and that only a small number of households have one or two people that are infirm or disabled.

Table 5.1: Socio-demographic characteristics of the sample and population

Variable		Sample distribution		Population distribution	Difference
Gender					
Male			49,8%	49,7%	0,1%
Female			50,2%	50,3%	-0,1%
Age					
20-34 years			35,4%	24,3%	11,1%
35-49 years			30,4%	24,4%	6,0%
50-65 years			28,0%	26,8%	-1,2%
65+ years			6,2%	24,8%	-18,6%
Education					
Lower-level education	*Primaryschool, VMBO-G, VMBO-T (mavo), havo, vwo- onderbouw, mbo2, mbo3, mbo 4, havo, vwo*		13,3%	30,1%	-16,8%
Middle-level education	*hbo, wo- bachelor*		44,7%	36,7%	8,0%
Higher-level education	*wo-master, doctor*		42,0%	31,5%	10,5%
Net household income class (€/year)					
Below average	€0 – €9.999	13,5%	5,2%	4,6%	0,6%
	€10.000 – €19.999		4,7%	24,0%	-19,3%
	€20.000 – €29.999		3,5%	32,0%	-28,5%
Average	€30.000 – €39.999	39,9%	9,8%	22,2%	-12,4%
	€40.000 – €49.999		30,1%	9,8%	20,3%
Above average	€50.000 – €100.000	36,6%	34,8%	6,7%	28,1%
	€100.000+		11,8%	0,6%	9,6%
Daily business					
Student			8,2%	4,5%	3,7%
Working			83,3%	52,2%	31,1%
Not working			8,6%	43,4%	-34,8%
Household compositions					
One person households	1		15,6%	38,3%	-22,7%
More person households	2	43,6%	84,4%	61,7%	22,7%
	3	17,5%			
	4	17,9%			
	5 or more	5,4%			
Average household size			2,54	2,15	0,39
Children		1	2		
0 - 5 years		22,5%	10,9%		
6 - 11 years		26,4%	6,9%		
12 - 17 years		22,2%	11,1%		
Number of people in the household that are infirm or disabled					
None			94,9%		
1 person			3,9%		
2 persons			1,2%		
*more than 5% difference					

5.4.2 Car use

As the choice for moving to a car restricted residential area may be affected by car use, it is also relevant to illustrate the car ownership and car use characteristics of the sample. The deviations between the sample and the population in car ownership and car use are presented in Table 5.2 and Table 5.3. The deviation between the sample and the population concerning car ownership is nihil. As indicated by the table, most households in the sample possess one vehicle, and a minor percentage of the households possess three or more vehicles. Thereby, most households privately own their car and fewer households possess their car based on business, lease, or private lease contract. As for the age of the car, most households possess a car older than one year. Comparing the sample and the population, the contribution of cars that are between one or two years old is higher in the sample, and the households in the sample compared to the households in the population have fewer cars that are older than 15 years. This may have implications for the research, as it is expected that people owning a (relatively) new car are less willing to park their car remotely.

Table 5.2: Car ownership characteristics of the sample and population

Characteristic	Sample distribution	Population distribution	Difference
Car ownership			
One vehicle	68,1%	67,7%	0,4%
two vehicles	25,7%	26,4%	-0,7%
three or more	6,2%	5,9%	0,3%
The base of car ownership			
Private	73,2%		
Business	9,7%		
Lease business	10,5%		
Private lease	6,6%		
Age of the most used vehicle			
Younger than 1 year	1,6%	4,9%	-3,3%
1 - 2 years	23,4%	10,4%	13,0%
3- 4 years	12,0%	9,9%	2,1%
5 - 6 years	10,1%	9,0%	1,1%
7- 8 years	10,9%	10,9%	-0,0%
9-12 years	15,5%	13,8%	1,7%
12 - 14 years	12,0%	12,7%	-0,7%
15- 19 years	9,7%	15,3%	-5,6%
20 - 24 years	3,2%	5,6%	-2,4%
25 years or older	1,6%	7,5%	-5,9%
*more than 5% difference			

The characteristics considering car use are presented in Table 5.3. The majority of the sample travels more than the average 13.000 kilometres per year (40,1%). This is corresponding to the frequency by which the car is used, as most of the sample use the car daily (41,2%) or at least several times a week (42,4%). Nevertheless, not many respondents indicated to use their car frequently during the night-time (i.e. between 22:00 and 6:00). Furthermore, cars are mostly used for only private purposes (44,7%) as well as both private and business purposes (47,9%). The contribution of the sample that possesses private parking is high, as 24,5% of the sample has a garage or driveway and 23,0% a private parking space in a public garage or parking lot. This may be the result of the deviation between the sample and the population concerning the uneven distribution of the residential areas (this will be elaborated in the next paragraph). However, almost half of the respondents having a private parking space may affect how people perceive the different parking types in a car restricted residential area. Especially people possessing a garage or driveway are expected to be less favouring living in a car restricted residential area. The high number of respondents that live in a G4 city (Amsterdam, Rotterdam, The Hague or Utrecht) (53,7%) may also correspond with the distribution of current parking paying arrangements in the sample. In most parts of these four cities, people have to pay for parking their car on the streets or car parking facilities are incorporated within buildings for which often parking spaces have to be bought. This corresponds with most respondents indicating to pay monthly for a parking space (43,2%) or bought a parking space conjointly with buying their residence (18,2%). Regarding the time between the residence and the car that respondents currently walk, the majority of the sample walks 1 minute (38,5%) or less (26,9%) between their residence and their car. The average walking time between the residence and the car is 3 minutes. Thus most respondents are not common with walking several minutes to their car, which may have a negative effect on how remote car parking facilities in a car restricted residential area are perceived.

Table 5.3: Car use characteristics of the sample

Characteristic		Sample distribution		Population distribution	Difference
Car use of most use car (kilometres/year)					
Below average	0 - 2.499 kilometres	36,2%	7,8%		
	2.500 - 4.999 kilometres		8,6%		
	5.000 - 7.499 kilometres		8,2%		
	7.500 - 9.999 kilometres		11,7%		
Average	10.000 - 12.499 kilometres	23,7%	14,0%		
	12.500 - 14.999 kilometres		9,7%		
Above average	15.000 - 19.999 kilometres	40,1%	14,0%		
	20.000 - 24.999 kilometres		5,1%		
	25.000 - 29.999 kilometres		5,1%		
	30.000 - 39.999 kilometres		7,8%		
	40.000 - 49.999 kilometres		3,1%		
	50.000 kilometres or more		5,1%		
Car use frequency					
Daily base			41,2%		
Weekly base			42,4%		
Monthly base			15,2%		
Yearly base			1,2%		
Car use frequency night (between 22:00 and 6:00)					
Daily base			2,3%		
Weekly base			18,7%		
Monthly base			42,0%		
Yearly base			37,0%		
Primarily purpose					
Private			44,7%		
Work-related			7,4%		
Private and business			47,9%		
Private parking place					
Yes, garage or driveway			24,5%		
Yes, private parking space in a public garage or parking lot			23,0%		
None			52,5%		
Current walking time to the car					
Less than 1 min			26,9%		
1 min			38,5%		
2 min			15,2%		
3 min			11,3%		
4 min			1,9%		
5 min			5,1%		
10 min			1,2%		
Average walking time to the car		3 min			
Current parking arrangement					
Yes, monthly costs			43,2%		
Yes, bought a parking place			18,2%		
None			38,6%		

5.4.3 Current residential environment

To examine the relationship between the current environment and the decision to move to a car restricted residential area, respondents were also asked to provide some answers about their current residential environment. First, when comparing the house ownership levels of the sample to the levels in the population, the sample consists, in comparison to the population, of a bigger composition of households that bought a house. This may have implications for the results, as it is expected that renters and buyers will value aspects of residential environments differently. Furthermore, the majority of the sample indicated to live in both the city centre as well as outside the centre of the city. The composition of respondents that live in rural areas is underrepresented (2,3%). As for the residential area, the sample distributions differ from the population distributions. The majority (53,7%) of the sample lives in one of the G4 cities; Amsterdam, Rotterdam, The Hague or Utrecht. Whereas in the population the majority of people lives outside the G4 cities. This may cause issues for the results as it is assumed that especially people living in a G4 city have different considerations about car restricted residential areas than people living outside G4 cities. Lastly, more than half of the sample (59,5%) does not have plans to move to a new residence within 5 years. Nevertheless, 27,2% of the sample has plans to move to a new residence within 1,5 years from now.

Table 5.4: Residential environment characteristics of the sample and population

Characteristic	Sample distribution	Population distribution	Difference
House ownership			
Rent	17,9%	41,5%	-23,6%
Buy	82,1%	58,5%	-23,9%
Living environment			
City centre	33,9%		
City off centre	40,8%		
Town centre	10,1%		
Town off centre	12,8%		
Rural	2,3%		
Residential area			
G4	53,7%	14,0%	39,7%
G40	17,1%	29,5%	16,8%
other	29,2%	56,5%	27,3%
Plan to move house			
Yes, now - 1,5 years	27,2%		
Yes, 1,5 - 5 years	13,2%		
None	59,5%		
*more than 5% difference			

Moreover, respondents indicated their current walking distances to the nearest car parking, green areas, supermarket, small range of facilities and a broad range of facilities (comparable to a city centre). The distribution of the walking times to these facilities are presented in Table 5.4. Most residents (71,2%) have the opportunity of parking their car adjacent to their house. Likewise, green areas are by around 50% of the respondents found within 3 minutes of walking time. The supermarket and 'small range of facilities' like a bakery, butcher, flower shop, pharmacy, etc., are mostly within 10 minutes of walking distance from the respondents' residences. Only 'broad range of facilities' is located at a further distance and for the majority of people (57,9%), these are within a 5- and 20-minutes range of walking.

Table 5.5: Distributions of walking time to parking facilities, green areas and facilities and services

	Walking time (minutes)								
Walking time to	adjacent to residence	less than 3	3 - 5	5 -10	10 -15	15 - 20	20 - 25	25 - 30	30+
Parking facilities	71,2%	23,0%	4,3%	-	0,4%	0,8%	-	-	0,4%
Green areas	18,7%	38,1%	19,5%	11,7%	7,4%	2,3%	0,8%	1,6%	-
Supermarket	3,1%	31,9%	31,5%	21,4%	8,6%	1,2%	-	0,4%	1,9%
Small range of facilities	3,5%	28,0%	30,4%	23,7%	7,4%	3,9%	0,4%	0,8%	1,9%
Broad range of facilities	0,4%	5,4%	8,9%	20,2%	23,3%	14,4%	10,9%	3,9%	12,5%

5.4.4 Attitudes

In the questionnaire, statements were also included to measure several attitudes regarding car use and car restricted residential areas. Furthermore, statements were presented to the respondents to measure their opinion about several characteristics in their current residential environment and their expectations about the same characteristics in a car restricted residential area. This section discusses the insights gained from the statements and their scores of residential environments. This is used to illustrate respondents' perspectives on car use and perceptions of a car restricted residential area.

Attitudes regarding car use and living environment

Table 5.6 presents the deviation of answers per statement that were given by the respondents, the means, and standard deviations of the measured attitudinal variables. All the attitudinal variables were measured on a five-point Likert scale, in which one equals 'strongly disagree' and five 'strongly agree'.

Table 5.6: Descriptive statistics regarding the attitudinal variables

	How often the answer was given in percentages					Mean	Std. dev.
	1	2	3	4	5		
22. A car gives me the feeling of freedom.	0,4	2,3	8,6	47,5	41,2	4,27	0,746
23. Without a car, I would feel very limited in what I can still do.	4,7	16,0	14,4	41,6	23,3	3,63	1,142
24. I need my car to do all of my activities properly.	7,0	21,4	15,2	36,6	19,8	3,41	1,222
25. I think travelling by car should be flexible.	2,3	2,3	19,5	52,1	27,3	3,93	0,856
26. I think I could live with a car less or without a car.	10,5	23,7	23,0	34,6	8,2	3,06	1,154
27. I find going to work without a car a hassle.	24,9	15,6	16,0	19,1	24,5	3,03	1,527
28. I consider the nearest parking space to my house as my own parking space.	19,8	28,8	18,7	24,1	11,3	2,75	1,301
29. I prefer to park my car in front of my house.	7,4	16,0	15,2	38,5	23,0	3,54	1,215
30. I drive extra laps until a parking space becomes available that is closer to my house.	26,8	30,7	21,0	15,6	5,8	2,43	1,204
31. I believe that having a car parking space near my home increases my home value.	1,9	10,1	21,0	47,9	19,1	3,72	0,952
32. I prefer to park my car as close to my house as possible when I have groceries with me.	2,3	3,1	8,2	38,1	48,1	4,27	0,911
33. I think it is important that shops and services are within walking distance of my home.	1,9	21,1	17,1	45,9	23,0	3,76	1,002
34. I think my living environment should be pedestrian friendly	2,7	7,0	12,1	50,2	28,0	3,94	0,962
35. I think it is important that children have a place in their living environment where they can play safely	2,3	5,1	6,6	36,6	49,4	4,26	0,954
36. I like to live in a green environment.	1,2	2,3	7,8	45,5	43,2	4,27	0,798
37. I like to live in a quiet environment.	2,3	9,7	25,3	35,4	27,2	3,75	1,034
38. I think it is important that I have contact with my neighbours.	3,9	10,5	24,1	42,4	19,1	3,62	1,032
39. I enjoy living in an environment where there are always people on the street.	3,9	16,3	36,2	35,4	8,2	3,28	0,963
40. I believe that high-density housing development should be encouraged.	9,7	29,2	42,0	12,1	7,0	2,77	1,017
41. I believe that a residential environment should be car-free.	5,4	19,8	35,0	30,4	9,3	3,18	1,032
42. I think cars pollute the street scene.	9,3	23,7	28,4	28,0	10,5	3,07	1,145
1 = strongly disagree *5 = strongly agree*							

Overall, there is a clear consensus that the car provides a feeling of freedom, flexibility, and comfort. 88,7% of respondents stated that a car gives a feeling of freedom. Furthermore, the majority of the people (64,9%) have the feeling that without a car they feel very limited in what they can still do, and that they need a car to perform all their activities properly (56,4%). Travelling by car should, overall, be flexible (79,4%). Nevertheless, people that disagree or agree with thinking that they can live with a car less or without a car are almost equally distributed (respectively 34,2% and 42,5%). Furthermore, people are divided about whether going to work without a car is a hassle or not (respectively 43,6% and 40,5%). These answers to these statements imply the sample to be car-dependent.

Considering the attitude about car parking the majority of the sample (61,5%) prefers to park their car in front of their house, especially when having groceries with them (68,9%). However, more than half (57,5%) of the sample indicates not willing to drive around for a while before a car parking space becomes available closer to their residence. Furthermore, 67,0% of the respondents believe that having a car parking near their residence increases their residence value. These distributions indicate that on average respondents highly value a car parking space close to their house.

A big component of the sample finds it important that their living environment is pedestrian-friendly (78,2%) and that shops and services are within walking distance from their home (68,9%). 42% of people do not disagree or agree with the consideration that high-density housing development should be encouraged.

Most respondents are very conscious of their living environment. 51,3% of the sample finds it important to have contact with their neighbours. Moreover, people strongly agree with the importance of children having a place in their living environment where they can play safely (86,0%). Most respondents like to live in a green environment (88,7%). Additionally, more than half of the respondents (62,6%) indicated to like living in a quiet environment.

Despite the strong value of the car in the sample, 39,7% of the sample believes that a residential environment should be car-free. On the other hand, 35% of the people do not agree or disagree with the statement and 25,3% disagrees. Additionally, a small majority of the sample (38,5%) thinks cars pollute the street scene, 23% disagrees and 28,4% is divided. Thus around one-third of the respondents support car restricted residential areas.

Push and pull factors for car restricted residential areas

Additionally, statements were included in the questionnaire to measure respondents' opinion about several characteristics in their current residential environment and their expectations about the same characteristics in a car restricted residential area. The difference between both scorings is considered to be the push or pull factor of a car restricted residential area. Respondents were asked to score both their current residential environment and their expectations of a car restricted residential environment in the following terms, for which the answers are presented in Tabl 5.7.

- Traffic safety
- The degree of traffic nuisance
- The amount of traffic
- Car parking availability
- Car parking accessibility from their home
- Presence of footpaths/sidewalks
- Presence of bicycle paths and bicycle parking places
- Presence of green areas
- Presence of facilities such as supermarket, shops and catering

Overall, in terms of traffic people find their current residential environment very safe (70%), are satisfied with the degree of traffic nuisance that they perceive (61,4%) and do not consider the amount of traffic in their residential environment as disturbing (66,8%). The majority of the sample expects that the traffic safety of a car restricted residential area is high (86,8%). However, people are divided about the degree of traffic nuisance and amount of traffic in car restricted residential areas and are distributed about those being low or high (respectively 47,9% and 42,%; 41,2% and 36,9%).

55,7% of the sample is satisfied with the availability of car parking in their current residential environment. Moreover, the majority is satisfied with the accessibility of car parking (80,3%). As assumed, the expectation of respondents of the car parking availability and accessibility is low for a car restricted residential area (respectively 40,9% and 46,7%).

Lastly, people scored the presence of walking and bicycle infrastructure, green areas and facilities in their current residential environment and the expectations they have about those variables in a car restricted residential environment. 92,6% of the sample was satisfied with the presence of footpaths and sidewalks in their current residential environment. Equally, people expect that the presence of pedestrian infrastructure is high in a car restricted residential area (89,9%). Furthermore, people were satisfied with the presence of bicycle infrastructure in their current residential environment and do expect that the presence of bicycle paths and bicycle parking places is high in car restricted residential environments as well (88,3%). 72% of the respondents are satisfied with the presence of green areas in their current living environment and 89,5% of the respondents expect that these will be present in car restricted residential environments as well. The presence of facilities such as supermarket, shops and catering in the current residential environment is found to be adequate (88,3%). On the other hand, most respondents seem to be divided about the presence of facilities such as supermarkets, shops and catering (38,1%) and only a minor majority (51,2%) of the respondents indicated to expect the presence of these facilities to be high in a car restricted residential environment. This may be because most retail facilities are located on places that are accessible by car, therefore a car restricted residential area may be perceived not to have a broad range of facilities such as supermarkets, shops and catering.

Table 5.7: Respondent's scoring of their current residential environment and a car restricted residential environment

	How often the answer was given in percentages					Mean	Std. dev.
	1	2	3	4	5		
Description of the current residential environment in the terms [a]							
Traffic safety	1,6	10,1	18,3	52,1	17,9	3,75	0,92
Degree of traffic nuisance	3,1	16,0	19,1	45,5	16,3	3,56	1,041
Amount of traffic	3,5	15,6	24,1	44,7	12,1	3,46	1,008
Car parking availability	6,6	19,5	18,3	40,5	15,2	3,38	1,154
Car parking accessibility from your home	2,3	7,0	9,3	45,5	35,8	4,05	0,971
Presence of footpath/sidewalks	0,4	2,3	4,7	60,7	31,9	4,21	0,671
Presence of bicycle paths and bicycle parking places	1,6	8,9	14,0	54,5	21,0	3,84	0,910
Presence of green areas	3,1	8,9	16,0	51,4	20,6	3,77	0,978
Presence of facilities such as supermarket, shops, and catering	1,2	1,2	9,3	60,7	27,6	4,12	0,713
Expectations of a car restricted residential environment [b]							
Traffic safety	1,9	2,3	8,9	58,4	28,4	4,09	0,798
Degree of traffic nuisance	18,3	29,6	10,1	30,4	11,7	2,88	1,338
Amount of traffic	16,3	33,9	12,8	26,8	10,1	2,81	1,278
Car parking availability	12,5	28,4	33,5	17,1	8,6	2,81	1,124
Car parking accessibility from your home	17,5	29,2	25,3	20,6	7,4	2,71	1,190
Presence of footpath/sidewalks	0,4	1,9	7,8	61,9	28,0	4,15	0,670
Presence of bicycle paths and bicycle parking places	0,4	2,7	8,6	59,5	28,8	4,14	0,708
Presence of green areas	0,8	1,2	8,6	51,8	37,7	4,25	0,722
Presence of facilities such as supermarket, shops, and catering	2,7	8,9	38,1	40,5	9,7	3,46	0,888
[a] 1 = very dissatisfied 5 = very satisfied [b] 1 = very low 5 = very high							

As indicated in Section 5.1.2 the difference in the above-described scoring of the current residential environment and car restricted residential environment is considered as push and pull factors for living in a car restricted residential environment. In case a respondent has higher expectations of a specific characteristic of a car restricted residential environment compared to the same character in their current residential environment, then this characteristic is considered as a pull factor for car restricted residential areas for this individual. This applies as well the other way around, a negative expectation of a specific aspect of a car restricted residential area is considered to be a push factor for moving to a car restricted residential area. The difference between the scorings of an individual respondent's is presented in Table 5.8.

The table content indicates that in terms of traffic, people consider car restricted residential environments to be slightly safer, less noisy, and less busy than their current residential environment. As anticipated, the expectation of the car parking availability and car parking accessibility of a car restricted residential environment is lower compared to the current residential environment.

Surprisingly, respondents expect that car restricted residential environments have a lower presence of footpaths/sidewalks and facilities such as supermarkets, shops, and catering. On the other hand, the presence of green areas and bicycle infrastructure is expected to be better represented in car restricted residential environments. The influence of an individual's expectations on their decisions to move to a car restricted residential area will be further analysed.

Table 5.8: Push and pull factors for living in a car restricted residential area

	Degree of the push or pull factor									Mean	Std. dev.
Push and pull factor car restricted residential environment [b]	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**		
Traffic safety	1,6	0,4	5,8	10,5	40,5	24,9	11,3	3,9	1,2	0,34	1,321
Degree of traffic nuisance	4,7	10,9	21,0	15,6	25,3	10,5	7,4	3,5	1,2	-0,68	1,778
Amount of traffic	2,3	10,1	20,6	21,4	20,6	16,3	6,6	0,8	1,2	-0,66	1,605
Car parking availability	0,4	8,6	20,2	26,5	21,0	14,8	4,7	2,7	1,2	-0,57	1,532
Car parking accessibility from your home	7,4	16,7	22,6	24,1	19,5	6,2	2,3	0,8	0,4	-1,34	1,523
Presence of footpath/sidewalks	0,4	1,2	4,3	19,5	54,1	16,3	2,3	1,9	-	-0,06	0,981
Presence of bicycle paths and bicycle parking places	0,4	0,4	3,9	14,0	49,9	21,4	10,5	2,7	0,8	0,29	1,146
Presence of green areas	-	0,8	3,9	14,4	35,8	25,7	13,6	4,7	1,2	0,47	1,248
Presence of facilities such as supermarket, shops, and catering	1,2	2,7	18,3	33,1	32,7	9,3	2,3	0,4	-	-0,67	1,138

4.5 Conclusion

The survey was completed by 330 people. Nevertheless, **one-third** of the people that opened the survey **dropped out of** the survey prematurely. The sample is **not representative** of the population, only in terms of gender. This may be the result of the selective bias introduced by the data collection process. It can be observed that the majority of the sample is middle- or high-level educated, as well as having an above-average household income. This may be the result of the locations where the survey was distributed as well as the result of self-selection of the respondents. Selectivity and non-representativeness can affect respondents' responses to certain questions and choice situations, which, accordingly, is observed in the characteristics and choice behaviour of the sample.

6
Model estimation

To form sufficient input for estimating the discrete choice models, non-linear variables measured by the survey are transformed into linear variables by coding them and the measured attitudes via the statements are constructed into latent variables (Section 6.1). The data set that followed is used to model the choices between the residential areas via a multinomial logit model and a mixed logit model (Section 6.2). The results of these estimations are presented and compared to determine which model results are used to interpreted and predict the willingness to move (Section 6.3). The chapter finalises with a conclusion of the model estimation results and a review of the model fit (Section 6.4).

6.1 Data preparation

After the evaluation of data, the data set included 257 observations that were used for further analysis. Subsequently, the non-linear variables were transformed into linear variables to facilitate the model estimation. Moreover, the attitudinal variables were constructed through factor analysis.

6.1.1 Coding of the variables

Since the attributes of the alternatives do not obtain an explicit base or average level effects coding is applied (Molin, 2018b). By using effects coding, the average utility contribution of the coded variables is fixed to zero. In this way, the utility contribution of an accompanying attribute level discloses the deviation from the average utility contribution of that variable. For consistency reasons effect coding is applied for the socio-demographic, car use and current residential environment variables as well. Table 6.1 indicates which variables are transformed and which coding scheme was applied.

The variables total kilometres travelled by car, educational level and household income level were considered nominal variables instead of ratio or interval variables. As the distances between the categories of these variables are not equal, these variables could not be considered as such. To reduce the number of variables that have to be estimated, the total kilometres travelled by car and household income variables are categorised in three levels; less than average, average and more than average, and the level of education in low, average and high level of education. A high number of variables would decrease the statistical power, raising the probability that a type II error is made (i.e. incorrectly assuming that a coefficient is not significant). Thus, to avoid a reduction of statistical power, next to frugality concerns, it was chosen to minimise the category levels of total kilometres travelled by car, level of education and household income.

Table 6.1: Overview of coded variables

Variable	Level	Coding			
Attributes of choice alternatives					
Type of car parking facility	*Private parking space in a parking garage*	1	0		
	Public parking garage	0	1		
	Public parking lot	-1	-1		
Type of building in the residential area	*Mainly* high-rise *building*	1	0		
	Mainly low-rise building	0	1		
	Mixed high and low-rise	-1	-1		
The liveliness level in the residential area	*Hardly people on the street*	1	0		
	Lively street scene with residents	0	1		
	Lively street scene with residents and trespassers	-1	-1		
Facilities in the residential area	*Only a supermarket*	1	0		
	A simple range of facilities	0	1		
	A broad range of facilities	-1	-1		
Green facility level in the residential area	*Small parks spread through the neighbourhood*	1	0		
	One big central park	0	1		
	Streets with wide grass strips & trees throughout the neighbourhood	-1	-1		
Socio-demographic variables					
Age	*20-34 years*	1	0	0	
	35-49 years	0	1	0	
	50-64 years	0	0	1	
	65+	-1	-1	-1	
Daily occupation	*Student*	1	0		
	Working	0	1		
	Not working	-1	-1		
Net yearly household income	*Below average (€0 – €39.000)*	1	0		
	Average (€40.000-€59.000)	0	1		
	Above average (€60.000+)	-1	-1		
Car use					
The total amount of yearly kilometres travelled by car	*Below average (0-9.999)*	1	0		
	Average (10.000-15.000)	0	1		
	Above average (15.000+)	-1	-1		
Frequency of car use	*Daily base*	1	0	0	
	Weekly base	0	1	0	
	Monthly base	0	0	1	
	Yearly base	-1	-1	-1	
Frequency of car use by night	*Daily base*	1	0	0	
	Weekly base	0	1	0	
	Monthly base	0	0	1	
	Yearly base	-1	-1	-1	
Purpose of car use	*Private*	1	0		
	Business	0	1		
	Private & Business	-1	-1		
Current parking paying arrangement	*Pays monthly for car parking*	1	0		
	Bought car parking space	0	1		
	No costs	-1	-1		
Ownership o private parking	*No*	1	0		
	Private garage or -driveway	0	1		
	Private parking space in a public garage or -parking lot	-1	-1		
Current residential environment					
Current living environment	*City centre*	1	0	0	0
	Off city centre	0	1	0	0
	Town centre	0	0	1	0
	Off town centre	0	0	0	1
	Rural	-1	-1	-1	-1
Current residential area	*G4*	1	0		
	G40	0	1		
	Other	-1	-1		
House ownership	*Rental*	1			
	Buy	-1			
Plan to move to a new house	*Yes, within 1,5 year from now*	1	0		
	Yes, in 1,5 to 5 years from now	0	1		
	No, not within 5 years from now	-1	-1		

6.1.2 Construction of attitudinal factors

The choice model will be enhanced with explanatory variables including attitudes regarding car use, residential environments and car restricted residential environments. As outlined in Section 4.2 multiple statements were included in the questionnaire to measure (underlying) attitudes on car use and car restricted residential areas. The underlying attitudes are constructed through factor analysis. These attitudes are formed of a combination of statements and combined into one summated scale representing the latent attitude.

For conceiving the underlying attitudinal factors, factor analysis is applied. As described in Section 2.3, this method aims to identify the correlation between measured attitudes and aggregates these in new dimensions. The observed attitudes are thus captured in new factors representing the underlying attitudes.

Preparing the factor analysis

Examination of the data

It was tested whether the data is adequate for performing factor analysis. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling adequacy and Bartlett's Test of Sphericity were used for this assessment (Bartlett, 1950; Field, 2000). In case the ratio respondents to variables is less than 1 to 5 it is recommended to assess the KMO. Although this criterion is sufficient, the test is still performed to make sure that the factor analysis can be performed. The results of the KMO test show a **KMO value of 0,760** is higher than the required value of 0,5, suggesting that the sample size is sufficient to perform factor analysis. The Bartlett's Test of Sphericity tests the examines whether the correlation matrix of the statements is an identity matrix, which indicates that the statements are unrelated and therefore unsuitable for structure detection. In other words, it checks if there is a correlation between the variables that can be summarised and captured in new factors. The **Bartlett's Test of Sphericity is significant**, indicating that the data is suitable for structure detection.

Determination extraction technique

The second step involves determining the factor extraction technique. Generally, two methods are applied for extracting the factors: (1) Principal Component Analysis (PCA) and (2) Principal Axis Factoring (PAF). These methods differ in the items that are placed on the correlation matrix's diagonal which being evaluated. The first method reports ones, while PAF reports the reliability estimates on the diagonal (Thompson & Daniel, 1996). In general, PCA concentrates on encapsulating multiple variables into a selection of components (i.e. the latent structures), whereas PAF focusses on the common variance between the variables (i.e. latent attitudes) (Henson & Roberts, 2006). Since this research achieves to identify the latent attitudes considering car use and car restricted residential areas **PAF** is used as the extraction method.

Limitation of factors

The third choice concerns the limitation of factors. Several rules are used, yet the **Kaiser criterion** is mostly applied. The Kaiser criterion entails that while a factor qualifies the condition of having an Eigenvalue higher it should be included in the analysis (Kaiser, 1960; Nunnally, 1978).

Selection of factor rotation method

The last step regards the factor rotation and interpretation and involves the decision on which factor rotation method that is applied. Factor rotation transforms the pattern of the factor loadings facilitating the interpretation of the factor structure. Two rotation techniques are used commonly: (1) orthogonal rotation and (2) oblique rotation. In orthogonal rotation, axes are rotated at a 90-degree angle, such that there is no correlation between the extracted factors, whereas in oblique rotation the factors are correlated (Field, 2000). For this study, first the orthogonal rotation ***varimax*** was used. This method does not allow a correlation between factors, providing a clear separation of factors, which makes factors easier to interpret. Yet, it may be that dimensions underlying the statements are correlated. Therefore, as an addition to the orthogonal rotation method, the oblique rotation method ***direct oblimin*** was applied, as this method allows factors to correlate (Field, 2009).

Performing the factor analysis

The factor analysis is performed with the software package SPSS (IBM, n.d.). A detailed description of the iteration steps of the varimax and direct oblimin rotation methods that were performed are provided in Appendix F.The outcomes of the factor analysis are displayed in Table 6.2, the factor structure resulting from the *direct oblimin* rotation is presented as this approached the simple structure solution better than the *varimax* rotation.

Table 6.2: The rotated factor-loading matrix resulting from the direct oblimin rotation

	Factor	
Indicators	1	2
Without a car, I would feel very limited in what I can still do. (2)	0,748	
I need my car to do all of my activities properly. (3)	0,714	
A car gives me the feeling of freedom. (1)	0,612	
I believe that parking space close to my home increases my home value. (10)	0,544	
I find going to work without a car a hassle. (6)	0,543	
I prefer to park my car as close to my house as possible when I have groceries with me. (11)	0,532	
I prefer to park my car in front of my house. (8)	0,505	
I think I could live with a car less or without a car. (5)	-0,483	
I consider the nearest parking space to my house as my own parking space. (7)	0,428	
I drive extra laps until a parking space becomes closer to my house. (9)	0,394	
I think travelling by car should be flexible. (4)	0,367	
I think it is important that children have a place in their living environment where they can play safely. (14)		0,634
I think it is important that I have contact with my neighbours. (22)		0,556
I like to live in a green environment. (15)		0,486
I believe that a residential environment should be car-free. (20)		0,427
I enjoy living in an environment where there are always people on the street. (18)		0,393
I think my living environment should be pedestrian-friendly. (13)		0,370
I think it is important that shops and services are within walking distance of my home. (12)		0,324

The results present a two-factor solution including 18 out of 21 variables. The first factor that is extracted is composed of statements in favour of car use. All the signs of the factor loadings indicate that the car is interwoven in the way of living. Therefore, this factor is considered to be *a car-oriented perspective*. The second factor is composed of statements indicating the importance of the neighbourhood. Accordingly, this factor will be addressed as *care for the quality of the living environment attitude.*

Testing internal consistency

Next, it was tested whether the coherence between the variables is high enough. Cronbach's Alpha will be used to measure the degree of consistency between the variables. Cronbach's Alpha scores higher than 0,7 are satisfying and indicate a high internal consistency between the variables (Bland & Altman, 1997). Factor 1 has a Cronbach's Alpha value of 0,767 and Factor 2 a value of 0,712. The internal consistencies of the variables from which the factors are composed are therefore considered suitable to include as latent factors in the choice model, and thus to construct summated scales.

Constructing summated scales

For each factor, summated scales were created by which the scores for each individual on these scales were determined. The scores were determined by summating the scores of the variables that together present the factor. The two factors with per individual the corresponding scores are added to the choice model to measure if the *car-oriented perspective* and *care for the quality of the living environment attitude* influence the choices to (not) move to a car restricted residential area.

6.2 Modelling the choices

The choice models are estimated with PhytonBiogeme (Bierlaire, 2016). However, before outlining the estimation process, first it is determined which models results will be outlined and used for interpretation: (1) the models including only the choice between the two car restricted residential alternatives or (2) the model including of an additional base alternative.

6.2.1 Determination of two alternative or three alternative choice models

Apart from the willingness to move to a car restricted residential area, this study is interested in the preference regarding the individual design variables of a car restricted residential area. There are two ways to determine the preferences of car owners regarding the design variables of car restricted residential areas. First, the choice model consisting of the choice between three alternatives: (1) moving to car restricted residential area one, (2) moving to car restricted residential area two and (3) moving to a conventional residential area. Secondly, there is a possibility of estimating a choice model only including the choice between moving to car restricted residential area (1) and moving to car restricted residential area (2). Estimating only the choice between the two car restricted residential areas, would provide more observations about how respondents value (the characteristics of) the residential areas against each other, which might result in more reliable parameter estimates. However, there is a risk that people are not making a well-considered decision when choosing between the two residential areas in the first question. There is a chance of respondents indicating in the second question not preferring to move to a car restricted residential area, might not be interested in these variables at all. Therefore, they might not make a well-considered trade-off between those variables in the first question and this might lead to people making more random choices between the two residential areas, which results in less reliable parameter estimates. To assess which MNL and ML model should be interpreted both models were estimated. The MNL and ML models estimated with only two alternatives had a lower Rho-square value (respectively 0,142 and 0,140) and the parameter estimates had a higher standard error, compared to the model including three alternatives (see Appendix H for an overview of the estimation outcomes). Therefore, it was chosen to elaborate on the model with three alternatives.

6.2.2 MNL model estimation

Initially, an MNL model is developed consisting of three alternatives; two car restricted residential areas and one opt-out alternative (moving to a conventional residential area). The model is specified by the two utility functions of the residential areas and base alternative. The ultimate MNL model is established by repeatedly extending the utility functions of the residential area alternatives. The model consisting of only the design variables of the residential areas that are altered in the alternatives in the choice experiment is considered the base model. As they represent the attributes of the alternatives, the model will always contain these variables, even if these variables turn out to be insignificant. Subsequently, it is scrutinized if it was possible to enhance the goodness-of-fit of the model by including the additionally measured variables of the survey in the model specification. These variables are arranged in the following clusters: (1) socio-demographic characteristics, (2) car use, (3) current housing and (4) attitudes concerning car restricted residential areas and car use. The corresponding variables were stepwise included in the model specification. The variables that are not significant are excluded from the model. The estimation of the basic model resulted in a Rho-square value of 0,187. In an iterative process of stepwise adding the socio-demographic, car use, current living environment and attitudinal variables to the model and subsequently removing the insignificant variables it was tested if each enhancement increased the model fit (at a 99% significance level) (see Table 6.3). Table

6.3 displays that the inclusion of socio-demographic variables contributes most to the model fit of the MNL model. Furthermore, the table presents the final MNL model including only the attributes and significant variables resulted in a Rho-square value of 0,235 and a Final log-likelihood value of -1.295.196. The corresponding values of the parameter estimates are included in Table 6.3. A detailed description of the model estimation and the formulation of the MNL model specification is provided in Appendix H.

Table 6.3 Model fit of estimated MNL models

Model	Number of parameters	Adjusted Rho-square	Final log-likelihood	LRS	Chi-square value (for p=0,01)
Null model	0	-	-1.694.060	-	
MNL basic	13	0,187	-1.377.418	633.284	27,69
MNL socio-demographic	19	0,368	-1.374.903	5.030	16,81
MNL car use	27	0,221	-1.319.901	110.004	20,09
MNL current living environment	29	0,234	-1.297.200	45.402	9,21
MNL attitudes	36	0,238	-1.291.681	11.038	18,48
Final MNL	33	0,235	-1.295.196	4.008	13,28

6.2.3 ML model estimation

Additional to the MNL model, a Mixed Logit (ML) model was developed. The estimation process was performed according to the same stepwise approach as used for estimating the MNL model. For the estimation of the model, Monte-Carlo simulation was applied, which uses draws taken from a normal distribution. In the estimation process of the ML model, the number of draws was repeatedly increased until the estimation results (i.e. parameter estimates, significance, Rho-square value and final Log-likelihood) became stable. Again, it was tested whether adjusting the model would lead to an increased model fit, if this was not the case then the adjustments should be considered not to improve the model and therefore should be removed from the model. First, nesting effects were captured in the model, meaning that the model takes into account the similarities between alternatives. Secondly, panel effects were included, which implies that the model considers that individuals made multiple decisions and that correlation between these decisions may exist. Subsequently, the possibility of people having different preferences regarding design variables were included, thereby allowing random taste heterogeneity among respondents. This last model was supplemented with the significant socio-demographic, car use, current residential environment and attitudinal variables of the MNL model. Again the insignificant variables were removed, which resulted in a final MNL model with a Rho-square value of 0,265 and a Final log-likelihood value of -1015.662 (see Table 6.4). Table 6.4 indicates capturing the nest between the car restricted residential area alternatives contribute little to the model fit. However, (1) including panel effects, (2) random taste heterogeneity and (3) the significant socio-demographic, car use, current residential environmental and attitudinal variables each enhance the exploratory power of the model by 3,5%. The model specification in terms of the utility formulation of the car restricted residential areas of the final ML model is displayed in Equation 6.1. For a detailed description the multiple estimated ML models Appendix H can be consulted. Table 6.5 displays the values of the parameter estimates.

$$
\begin{aligned}
Ucarfree = {} & ASC_{carfree} + \upsilon_{carfree} + \beta_{Time} * Time + \beta_{Type_{eff1}} * Type_{eff1} + \beta_{Type_{eff2}} * Type_{eff2} \\
& + \beta_{Price} * Price + \beta_{Building_{eff1}} * Building_{eff1} + \beta_{Building_{eff2}} * Building_{eff2} \\
& + \beta_{Live_{eff1}} * Live_{eff1} + \beta_{Live_{eff2}} * Live_{eff2} + \beta_{Facilities_{eff1}} * Facilities_{eff1} \\
& + \beta_{Facilities_{eff2}} * Facilities_{eff2} + \beta_{Green_{eff1}} * Green_{eff1} + \beta_{Green_{eff2}} * Green_{eff2} \\
& + \beta_{interaction_{Time*housholdsize}} * hhsize * Time + Beta_{interaction_{Time*kidsyoung}} * kids_{young} \\
& * Time + \beta_{car\ use\ eff1} * car\ use_{eff1} + \beta_{car\ purpose\ eff1} * car\ use_{eff1} \\
& + \beta_{interaction_{Price*current\ walking\ time}} * c_{time\ parking} * Price \\
& + \beta_{interaction_{Price*current\ parking\ costs}} * car_{parking\ costs_{eff1}} * Price \\
& + \beta_{interaction_{Price*parking\ costs_{eff2}}} * car_{parking\ costs_{eff2}} * Price + \beta_{house\ own} * house\ own
\end{aligned}
\tag{6.1}
$$

Where:

$\upsilon_{carfree} \sim N\ (ASC_{carfree}, \sigma_{\upsilon_{carfree}})$

$\beta_{Time} \sim N\ (\beta_{Time}, \sigma_{\beta_{Time}})$

$\beta_{Building_{eff1}} \sim N\ (\beta_{Building_{eff1}}, \sigma_{\beta_{Building_{eff1}}})$

$\beta_{Live_{eff1}} \sim N\ (\beta_{Live_{eff1}}, \sigma_{\beta_{Live_{eff1}}})$

$\beta_{Green_{eff2}} \sim N\ (\beta_{Green_{eff2}}, \sigma_{\beta_{Green_{eff2}}})$

Table 6.4: Model fit of estimated ML models

Model	Number of parameters	Adjusted Rho-square	Final log-likelihood	LRS	Chi-square value (for p=0,01)
Null model	0		-1.694.060		
MNL Basic	13	0,187	-1.377.418	633284	27,69
ML Basic (100 draws) including: - nesting effects	14	0,162	-1.377.367	102	6,63
ML Basic (100 draws) including: - nesting effects - panel effects	14	0,206	-1.058.335	638166	6,63
ML Basic (200 draws) including: - nesting effects - panel panel effects - random taste heterogeneity	18	0,231	-1.043.092	15.243	13,28
ML extended (200 draws) including: - nesting effects - panel panel effects - random taste heterogeneity - socio-demographic, car use, current residential environment, and attitudinal variables	26	0,265	-1.015.622	27.470	20,09

6.3 MNL and ML model results

Table 6.5 displays the results of the final MNL model and the final ML model. The results will be compared in Section 6.3.1 and the model fit of both models will be discussed in Section 6.3.2.

6.3.1 MNL and ML model comparison

The results in Table 6.5 show that multiple variables that seemed to significantly influence the willingness to move to a car restricted residential area, as indicated by the results of the MNL model, do not significantly affect the car owners' willingness to move as expressed by the results of the ML model. This difference originates in the assumptions of the MNL model, that may lead to incorrect estimation outcomes (Appendix H).

The table content furthermore displays the Rho-square values of the MNL and ML models. The higher the Rho-square value of the ML model the better the ML model performs in explaining the data compared to the MNL model. This conclusion is supported by the Ben-Akiva and Swait test, which allows assessing if the ML significantly outperforms the MNL model (Ben-Akiva & Swait, 1986) (see Appendix H).

6.3.2 Goodness-of-fit

The Rho-square value of 0,265 which is reported in Table 6.5, this value expresses the performance of the model. The value of 0,265 signifies that 26,5% of the initial uncertainty can be explained by the model. Thus, compared to having no understanding of car owners' choice behaviour considering the willingness to move to a car restricted residential area, the model is able to clarify 26,5% of the choice behaviour. Yet, at the same time, this indicates that the choice behaviour of respondents is dependent on more than the observed variables only.

6.4 Conclusion

The results of the three alternative choice models indicate to be a better predictor for the choice behaviour of car owners over the two alternative choice models. Furthermore, the results of the mixed logit model imply that the ML model performs better than the multinomial logit model. Therefore, the results of the ML model will be used to interpreted and predict car owners' willingness to move to a car restricted residential area.

Table 6.5: Results of the MNL- and ML model

Variable	MNL Model				ML model			
	Value	Standard error	t-test	p-value	Value	Standard error	t-test	p-value
Alternative specific constant car restricted residential area	-1,34	0,273	-4,92	0,00	-2,16	0,404	-5,34	0
Attributes of the alternatives								
Walking time to the car parking facility	0,103	0,0367	2,81	0,00	0,0787	0,0257	3,06	0,00
Type of car parking facility								
Private parking space in a parking garage (1)	-0,184	0,0849	-2,17	0,03	-0,214	0,112	-1,91	0,06*
Public parking garage (2)	0,0426	0,0727	0,59	0,56*	0,191	0,0988	1,94	0,05*
Monthly parking costs	0,00148	0,000785	1,88	0,06*	0,00285	0,00102	2,79	0,01
Type of building in the car restricted residential environment								
Mainly high-rise building (1)	0,107	0,104	1,03	0,30*	-0,0173	0,0756	-0,23	0,82*
Mainly low-rise building (2)	-0,309	0,102	-3,04	0,00	-0,223	0,142	-1,56	0,12*
Liveliness level in the car restricted residential environment								
Hardly people on the street (1)	-0,352	0,0893	-3,94	0,00	-0,221	0,0616	-3,59	0,00
Lively street scene with residents (2)	-0,0296	0,0781	-0,38	0,70*	0,0298	0,0947	0,32	0,75*
Facilities in the car restricted residential environment								
Only a supermarket (1)	0,162	0,102	1,58	0,11*	0,338	0,143	2,37	0,02
A simple range of facilities (2)	-0,326	0,0922	-3,53	0,00	-0,288	0,127	-2,28	0,02
Green facility level in the car restricted residential environment								
Small parks spread through the neighbourhood (1)	0,208	0,0736	2,83	0,00	0,154	0,0973	1,58	0,11*
One big central park (2)	-0,316	0,0837	-3,78	0,00	-0,199	0,0614	-3,23	0,00
Socio-demographic variables								
Household size	0,194	0,0726	2,67	0,01				
Interaction between Walking time to the car parking facility and household size	-0,0501	0,013	-3,84	0,00	-0,0776	0,0189	-4,11	0,00
Interaction between Walking time to the car parking facility and kids between 0 – 5 years	0,0543	0,0188	2,89	0,00	0,139	0,0378	3,69	0,00
Car use								
Frequency of car use								
Daily base (1)	-0,571	0,153	-3,73	0,00	-1,28	0,457	-2,8	0,01
Weekly (2)	-0,295	0,137	-2,16	0,03				
Purpose of car use								
Private (1)	-0,314	0,0656	-4,79	0,00	-0,66	0,248	-2,66	0,01
Current walking time to the car								
Interaction between Monthly parking costs and Current walking time car to the car	-0,00202	0,000329	-6,15	0,00	-0,00214	0,000487	-4,39	0,00

Variable	MNL Model				ML model			
	Value	Standard error	t-test	p-value	Value	Standard error	t-test	p-value
Age of the car								
Interaction between Monthly parking costs and Age of the car	0,000127	3,82E-05	3,33	0,00				
Current parking paying arrangement								
PC2 (Bought a car parking space)	-0,934	0,14	-6,70	0,00				
Interaction between Monthly parking costs and Pays monthly for car parking (1)	-0,00263	0,000629	-4,18	0,00	-0,0024	0,000893	-2,69	0,01
Interaction between Monthly parking costs and Bought a car parking space (2)	0,00524	0,000842	6,23	0,00	0,00477	0,00109	4,37	0,00
Private parking ownership								
Private garage or driveway (2)	-0,367	0,106	-3,45	0,00				
Current residential environment								
Living environment								
Off centre city (2)	-0,399	0,116	-3,45	0,00				
Residential area								
G4 citiies (1)	0,227	0,0885	2,56	0,01				
House ownership	-0,365	0,0853	-4,29	0,00	-0,636	0,289	-2,2	0,03
Plan to move to a new house								
Yes, within 1,5 year from now (1)	-0,205	0,0923	-2,23	0,03				
Yes, in 1,5 to 5 years from now (2)	0,302	0,11	2,76	0,01				
Attitudes								
Attitudinal factors								
Quiet living attitude (factor 2)	-0,00384	0,00141	-2,73	0,01				
Interaction between Monthly parking costs and Quiet living attitude (factor 2)	1,20E-05	5,41E-06	2,21	0,03				
Interaction between Walking time to the car parking facility and Quiet living attitude (factor 2)	0,000566	0,00019	2,98	0,00				
Sigmas								
Alternative specific constant car restricted residential area					4,02	0,373	10,77	0,00
Walking time to the car parking facility					0,0756	0,0242	3,12	0,00
Mainly high-rise building (1)					-0,706	0,163	-4,34	0,00
Hardly people on the street (1)					0,437	0,141	3,1	0,00
One big central park (2)					0,345	0,119	2,9	0,00
Log-likelihood (LL)	-1.295.196				-1015.662			
Adjusted Rho-square value	0.235				0.265			
* Not significant at 95% significance level								

7

Model interpretation: Preferences regarding car restricted residential areas

The results of the mixed logit model including three alternatives are interpreted and determine car owners' preferences regarding car restricted residential areas and their design variables (Section 7.1). Moreover, the effect of socio-demographic variables, car use, current residential environment and attitudes are discussed (Section 7.2). These insights are used to determine the relative importance of the variables (Section 7.3). These insights are bundled which is used to illustrate the part-worth utilities per variable and conclude on which variables are preferred by car owners and which are not (Section 7.4).

7.1 Preferences regarding car restricted residential areas and their design variables

The average preference for moving to a car restricted resdential area will be described next to car owners' preference for car parking characteristics and physical environment characteristics in a car restricted residential area.

7.1.1 Preference for moving to a car restricted residential area

The alternative specific constant of car restricted residential areas captures the total utility that is associated with living in a car restricted residential area which could not be captured in the observed variables (e.g scepticism about the operationalisation of a car restricted residential area). The (average) association people have with living in a car restricted residential area, other than the association with observed variables, is negative (-2.16).

Nevertheless, there is a high degree of unobserved taste heterogeneity in the value people derive from moving to a car restricted residential area (sigma value of 4,02). Thus, on average people prefer not to move to a car restricted residential area, still, this preference varies across individuals (see Figure 7.1).

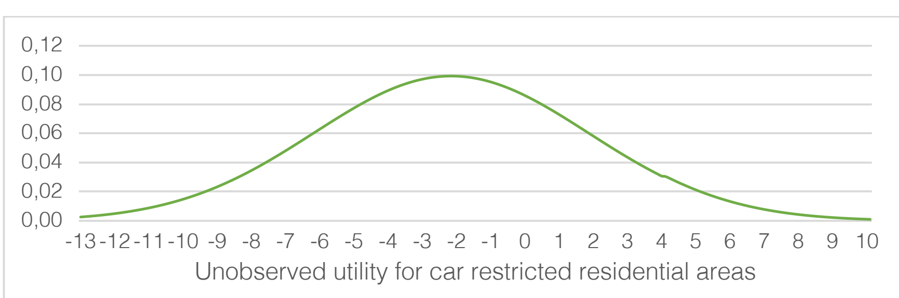

Figure 7.1: Probability density function of the alternative specific constant for car restricted residential areas

7.1.2 Walking time to the car parking facility

Considering the design variable walking time to the car parking facility, on first sight, it seems that the respondent's average preference for the walking time between their residence and car is slightly positive (0,0787/minute). Nonetheless, there is a small degree of unobserved taste variation between respondents considering walking time to the car (sigma value of 0,0756), which means that people are heterogeneous in liking or disliking the walking time to the car (see Figure 7.2).

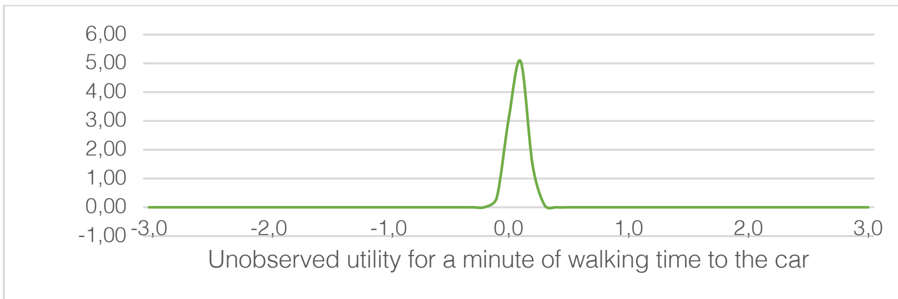

Figure 7.2: Probability density function of β for the walking time to the car parking facility

Influence of household composition

However, more importantly, household size and household composition, namely the number of children between 0-5 years old, were found to relate to how people perceive the walking time to the car parking facility.

Household size

Household size negatively relates to how people perceive the walking time to the car (-0,776). The bigger the size of the household, and the longer the walking time to the parking facility, the fewer people prefer moving to a car restricted residential area. This may be the result of people with bigger household sizes finding remote parking more difficult. The high composition of more person households in comparison to the population (see Section 5.3) may distort the influence of household size on the retrieved disfavour for remote parking. Therefore the influence of household size on how people perceive walking time to the car parking facility may not be a good predictor for the population. However, the average household size does not differ much between the sample and the population, therefore the first deviation may not distort the influence to a great extent.

Number of children in the age of 0 to 5 years old

Furthermore, there is a relation between the number of children in the age category of zero to five and walking time to the car (0,139). Households with one or more children up to five years old prefer to walk further to their car. It may be that parents of children in this age category associate the walking time to the car parking facility with the range in which there is no vehicular activity from their residence (longer walking time equals a bigger range). Which may implicitly be associated with the range in which their children can walk and play safely on the streets.

Total utility associated with various walking times

The last finding is in contrast to the negative perception of walking time by bigger household sizes. Therefore the effects on the total utility retrieved from various walking times to the car parking facility for different household compositions are visualised (see figures 7.8, 7.9 and 7.10). First, Figure 7.8 displays that each household not including children in the age category zero to five does not perceive walking to a car parking facility as positive. Figure 7.9, on the other hand, shows that a two-person household including one child in the age category zero to five do value walking time to the car parking facility slightly positive. At last, Figure 7.10 indicates that only three and four-person households with two children between zero and six years old have a positive association with remote car parking.

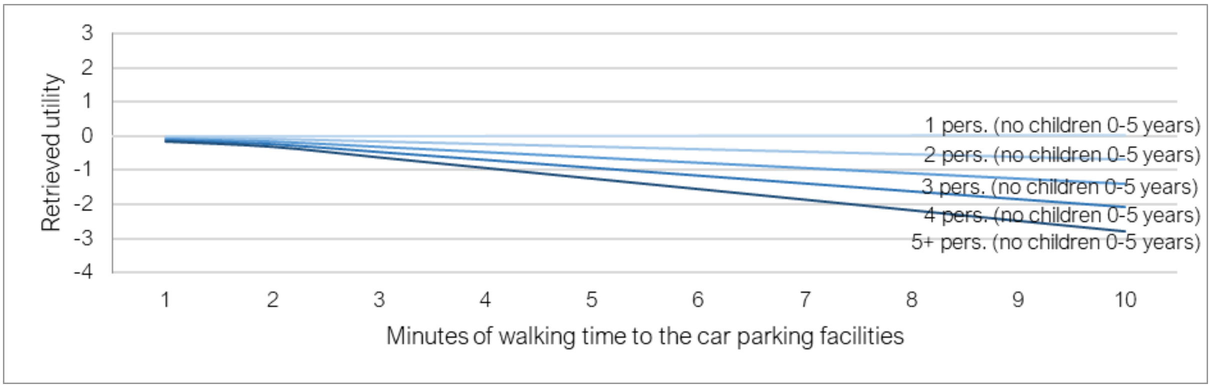

Figure 7.3: Retrieved utility for walking time to the car parking facility for a household with no children between 0 - 5 years old

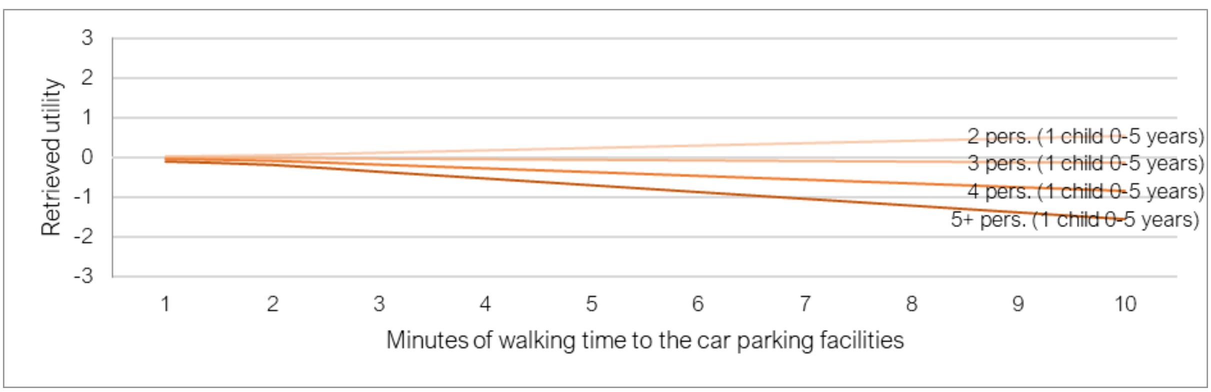

Figure 7.4: Retrieved utility for walking time to the car parking facility for a household with one child between 0 - 5 years old

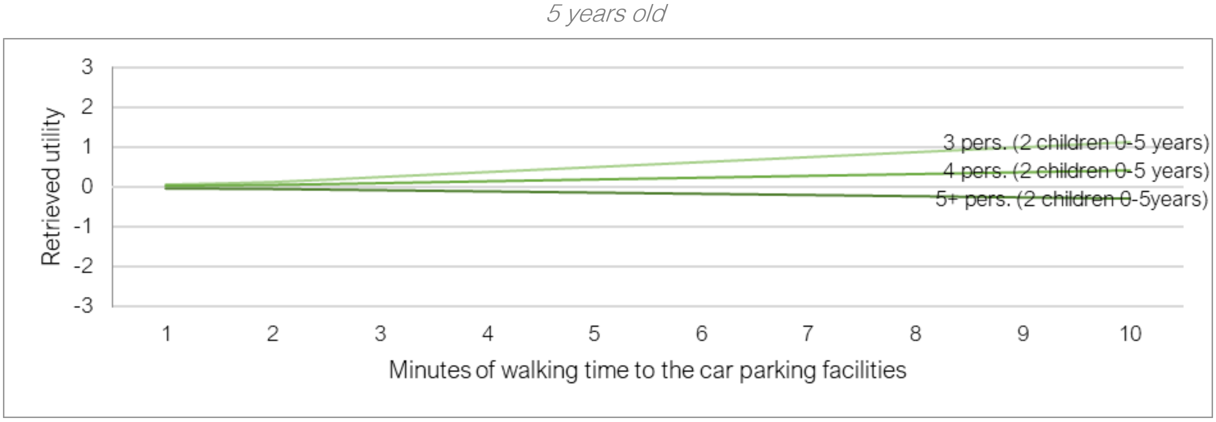

Figure 7.5: Retrieved utility for walking time to the car parking facility for a household with two children between 0 - 5 years old

7.1.3 Type of car parking facility

On average private parking space in a parking garage is seen as unfavourable (-0,214). However, there is a preference for a public parking garage (0,191). As these estimated values are only slightly insignificant (p-values of respectively 0,06 and 0,05), these results still provide remarkable information, as it was expected that people would value a private parking space in a parking garage over a public parking garage. Perhaps people associate a public parking garage to be less expensive than a private parking spot in a garage. Moreover, a public parking garage may be perceived as safer since a private parking garage is more exclusive, hence less activity occurs. This may be perceived to increase the risk of violence or burglary.

7.1.4 Monthly parking costs

Furthermore, on first sight there seems to be a positive preference for monthly parking costs (0,0028/€). Since people generally minimise their costs, this outcome was unexpected.

Influence of car use variables

However, respondents' current walking distance to the car and current parking arrangements were found to influence how people perceive the monthly parking costs.

Current walking time to the car

The time people currently walk to their car interacts with the monthly parking price arrangements of a car restricted residential areas. People who currently spend several minutes walking to their car do not prefer to pay (more) for parking in a car restricted residential area (-0,00214/min-euro). Figure 7.6 displays the total utility that is derived from monthly parking costs in a car restricted residential area with regard to the current walking times to people's cars. The figure shows that only people currently parking adjacent to their residence or walking maximally one minute to their car, are willing to pay more for parking in a car restricted residential area. It could be that people indirectly related the parking costs to parking distance and therefore are prepared to pay more with the expectation that they are can park their car more closely to their residence.

Current parking arrangements

Lastly, when having to pay for car parking facilities in a car restricted area, people currently paying periodically do not prefer to pay for car parking in a car restricted residential area (-0,0024/€), whereas people that bought a private parking place are in favour the monthly parking costs in a car restricted residential area (0,00477/€). This may be because people that currently invested in car parking, do see the advantage of investing in car parking in a car restricted residential area and people that monthly paying for parking their car perceive it more as a burden. Still, when reviewing the total utility that people retrieve from the monthly car parking costs with regard to their current car parking arrangements, both people that pay monthly for car parking and bought a car parking spot have positive associations with monthly car parking costs (see Figure 7.12).

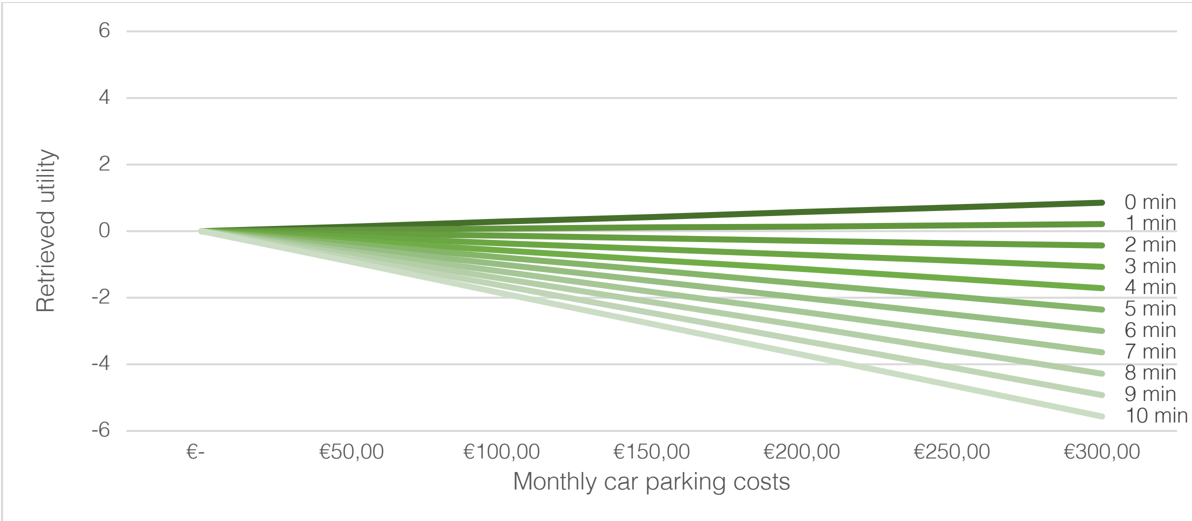

Figure 7.6: Retrieved utility for monthly car parking costs with regard to current walking times to the car

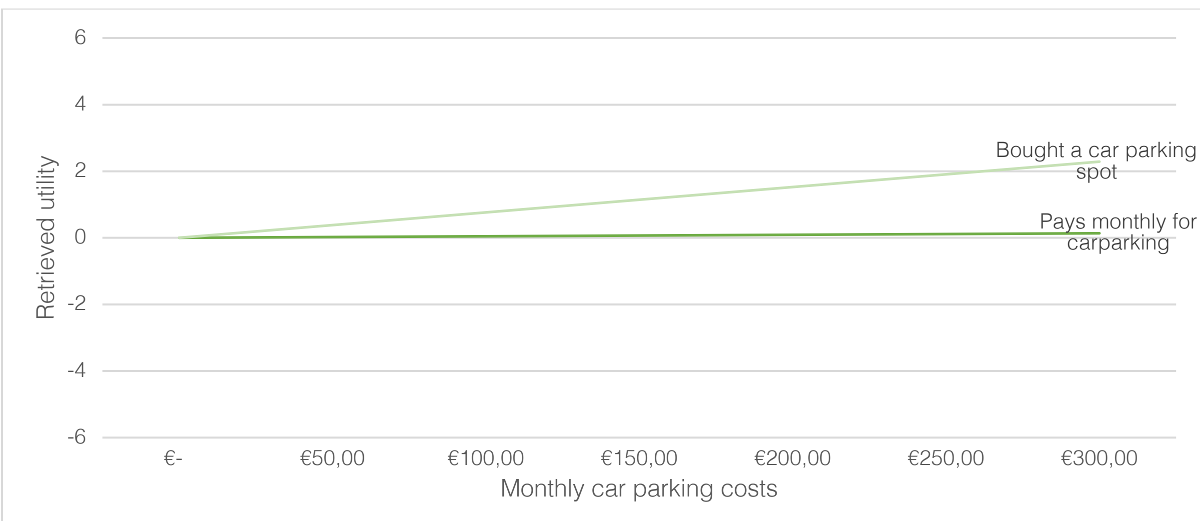

Figure 7.7: Retrieved utility for monthly car parking costs with regard to current parking arrangements

7.1.5 Type of building in the car restricted residential environment

There was no significant preference for the two levels of the type of building in the car restricted residential environment. However, the results indicate that mainly low-rise building was valued more negatively (-0,223 p-value of 0,82) than mainly high-rise building (-0,0173; p-value of 0,12). As the building environment of respondents' current housing was not observed, it may be that the people that prefer to move to a car restricted residential area currently live in a high-density building environment and thus value mainly high-rise building less negatively than mainly low-rise building. Furthermore, there is a varying unobserved taste for high buildings within the sample (sigma value of –0,706), which means that respondents have heterogeneous associations with high-rise building (see Figure 7.8).

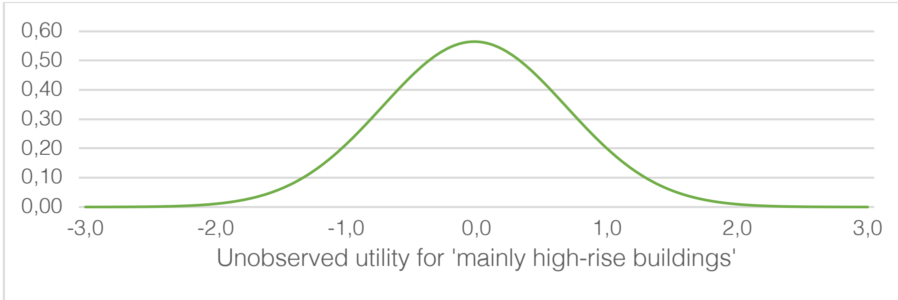

Figure 7.8: Probability density function of the β for 'mainly high-rise buildings'

7.1.6 Liveliness level in the car restricted residential environment

On average, having hardly any people on the street was valued negatively (-0,221) and people have positive associations towards a lively street scene with residents (0,0298), although the last was not valued significantly different from the average preference for the liveliness level in a car restricted residential environment (p-value of 0,75). Moreover, respondents seem to vary in their taste considering the preference for hardly having people on the streets, as there is a preference for not having people on the street (sigma value of 0,345).

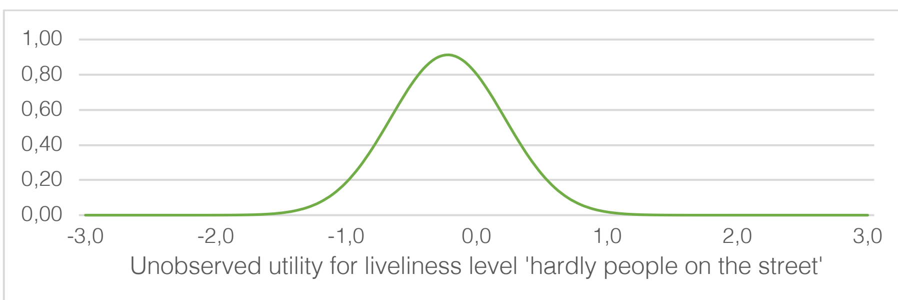

Figure 7.9: Probability density function of the β for liveliness level 'hardly people on the street'

7.1.7 Facilities in the car restricted residential environment

Considering the facilities that are offered in the neighbourhood, people valued 'only having a supermarket' positively (0,338) while a 'simple range of facilities' is not preferred (-0,288). It was expected that people would prefer having a broader range of facilities over only a supermarket. However, it may be that, as supermarkets nowadays offer a broad range of products that covers most of the products that the simple range of facilities offer. Therefore, it may be that people do not prefer the addition of a small range of facilities to a car restricted residential area.

7.1.8 Green facility level in the car restricted residential environment

Lastly, the preference for the design of green facilities in car restricted residential areas is regarded. Respondents preferred small parks that are spread throughout the neighbourhood (0,154; p-value of 0,11), while one big central park is not favoured (-0,199). However, only the preference for one big central park turned out to be significantly different from the average retrieved utility for this attribute. Thus, on average, there is only a negative taste for one big central park. This may result from the fact that people have to walk further to a central park in comparison to multiple green areas spread through the neighbourhood. Additionally, to some extent, there is an unobserved variation for the taste about the green facility-level ‘one big central park’ (sigma value of 0,0756), which indicates that there are people that value a big central park positively and negatively.

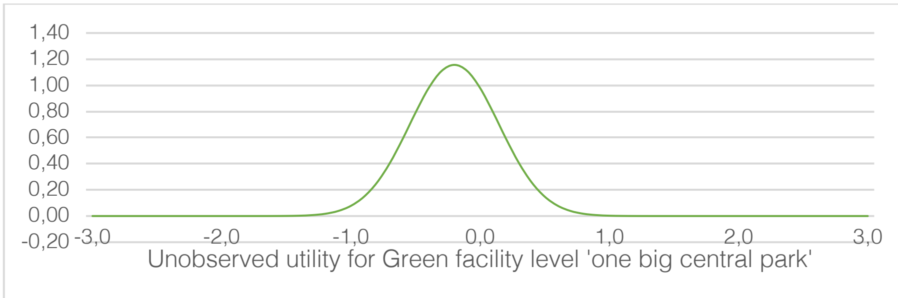

Figure 7.10: Probability density function of the β for green facility-level ‘One big central park’

7.2 The effect of socio-demographic variables, car use, current living environment and attitudes

Next to the design variables of the car restricted residential area, the ML model was enhanced with socio-demographic variables and variables indicating car use, current residential environment, and attitudes. The effects of household composition on how people perceive walking time and the influence of current walking time to the car and current car parking arrangements on the association with monthly parking costs are already discussed. Additionally, the frequency of car use, and the primary purpose of the car use, next to the house ownership arrangement significantly influence the willingness to move to a car restricted residential area.

7.2.1 Car use

Frequency of car use

First of all the frequency of car use turned out to affect their willingness to move to these residential areas. On average people that use their car daily do not prefer to live in a car restricted residential area (-1.28). This may be the result of people that use the car daily perceive more hinder from parking their car remotely as walking to their car this will take more time.

Primarily private usage

Moreover, the purpose for which the car is used relates to this preference, as people who use their car for only private purposes are not in favour of moving to a car restricted residential area (-0,66). This may be caused by the feeling that parking a car remotely, and thus the time it takes to walk to the car is associated with the time that could be spent on private activities.

7.2.3 Current residential environment

House ownership arrangement

The house ownership arrangement of respondents influences the willingness to move to a car restricted residential area. People currently **owning a residence** do prefer to live in a car restricted residential area (0,636) while people currently **renting a residence** do not wish to live in a car restricted residential area (-0,636). Since purchasing a residence is a long-term investment, it may be that house purchasers take the residential area in which they buy their residence more into consideration. This may result in assigning more value to a car restricted residential area. However, as the high distribution of house owners in the sample is unrepresentative for the population, the influence of house ownership arrangement on the willingness to move to a car restricted residential area in the sample may not be a good predictor for the influence of the preference in the population.

7.2.4 Attitudes

Lastly, the influence of attitudes regarding car use and car living environment on the willingness to move to a car restricted residential area was assessed. Both the 'car-oriented attitude' and 'the quality of the living environment attitude' did not influence the intention to move to these types of areas. Furthermore, the interaction between these attitudes and how people perceive the walking time to the car parking facility and parking price did not seem to influence the willingness for living in a car restricted residential area. Moreover, the push and pull factors for living in a car restricted residential area did not influence this willingness.

7.3 The relative importance of the variables

The estimation results were used to indicate the importance of the variables. The importance of each variable can be quantified by calculating the variables' relative importance based on the coefficients and the value range of every variable. The value range of each attribute is the difference between the highest and the lowest estimated part-worth utility of the corresponding levels. By summing the ranges of all the variables, the percentual contribution of each variable can be determined (see Appendix I for a detailed description of the calculation). The resulting relative importance of each variable is presented in Figure 7.11.

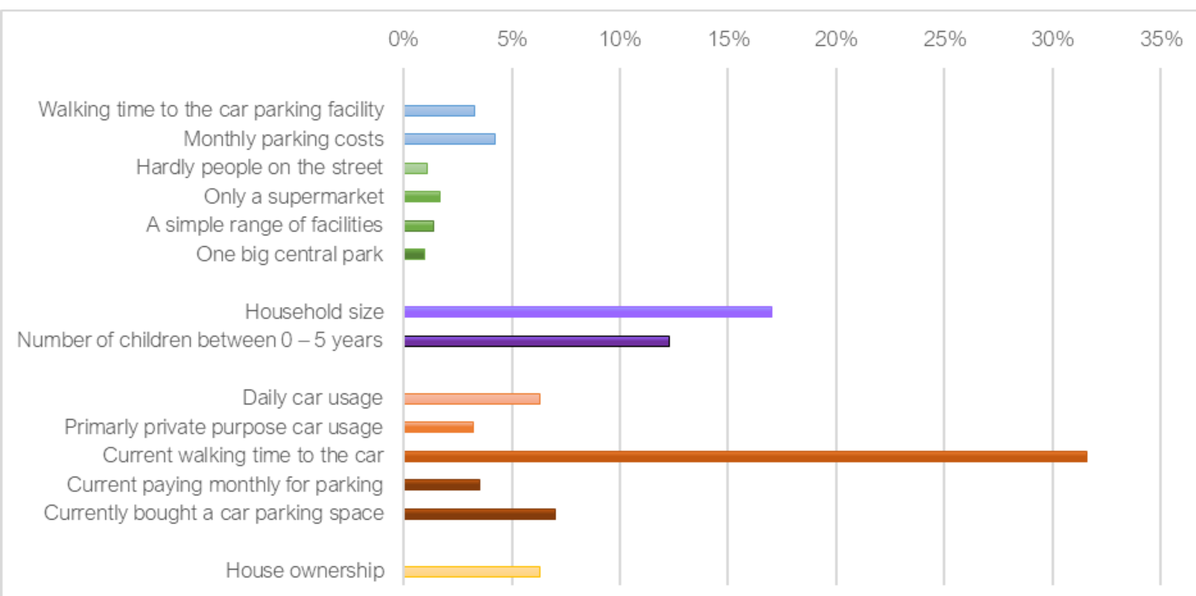

Figure 7.11: Relative influence of variables on the willingness to move to a car restricted residential area

The figure displays that the design variables together make up for around 10% of the relative importance. However, of these attributes, the walking time to the car parking facility and monthly car parking costs seem to have the highest relative importance of respectively 3,3% and 4,2%. And the design variables 'hardly people on the street', 'only a supermarket', 'a simple range of facilities' and 'one big central park' are the least important variables. Moreover, the figure shows that people's current walking time to the car by far is the most important variable, with a relative importance of 31,6%. This is followed by household size and the number of children in the age category 0-5 years, with a relative importance of respectively 17,0% and 12,3%. The other variables representing car use, such as daily usage, primarily private purpose usage and the monthly car parking arrangements all have a relative importance around 5%. Furthermore, current house ownership arrangements (i.e. resident owners and resident renters) has a relative importance of 6,3%.

7.4 Conclusion

This chapter discussed the results of the ML model in terms of the preferences regarding the design variables and the effects of socio-demographic, car use, current residential environment and attitudinal variables. The main outcomes considering the negative or positive associations per design variable and the influences of socio-demographic, car use and the current residential environment are summarized in Figure 7.12.

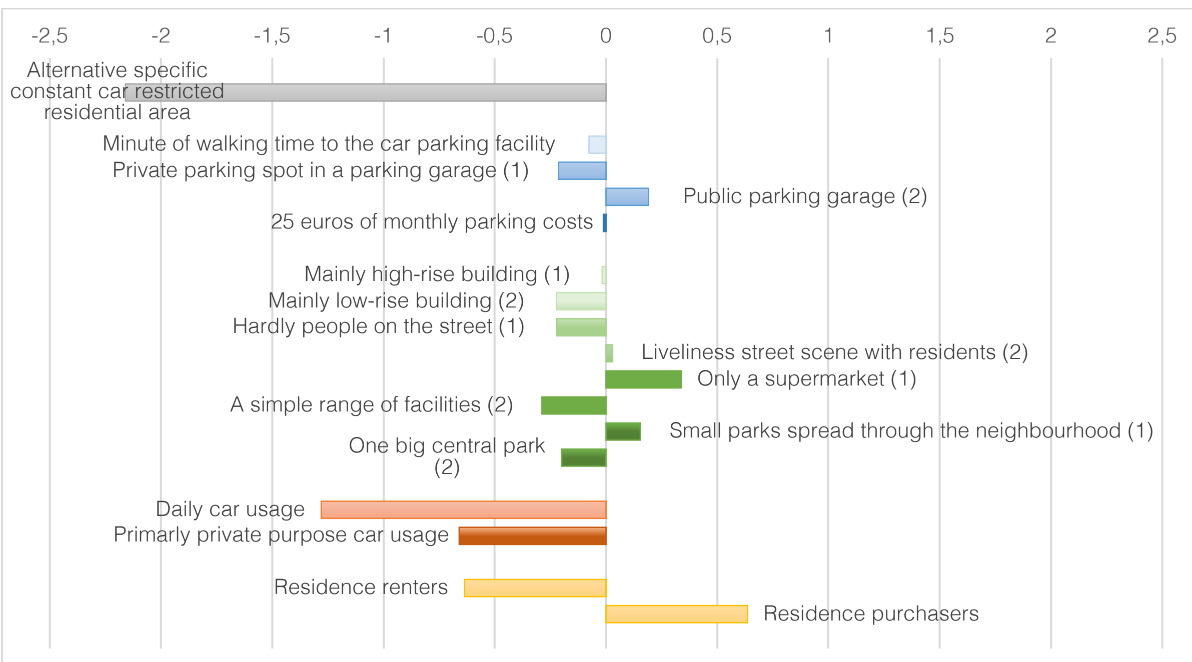

Figure 7.12: Retrieved utility per variable

The most important conclusions that can be drawn are:

- On average there is a dislike for moving to a car restricted residential area. However, there is a high level of unobserved heterogeneity in the willingness to move to a car restricted residential area. This means that there is a variety in the willingness to move to a car restricted residential area that cannot be disclosed by the observed variables
- At first sight, it seems that people have a positive association with walking to the car parking facility. However, when taking into account the household composition, the positive association is levelled out. It can be concluded that only two-person households with 1 child in the age category of 0 to 5 years, and three and four-person households with 2 children in

the same age category value remote car parking facilities positively. Furthermore, there is some unobserved heterogeneity in the preference for walking time to the car, meaning that there is some variety of car owners liking or disliking walking time to the car parking.

- Car owners currently parking their car on a walking distance of 1 minute or less do not mind paying for parking their car in a car restricted residential area. Moreover, especially people that currently bought a car parking spot do not refrain for the monthly car parking costs.
- People value high-rise buildings in a car restricted residential area differently.
- People on average do not prefer a car restricted residential area in which there is hardly any movement of people on the streets, yet there is some level of variation in this taste.
- A car restricted residential area with only a supermarket is liked, and a car restricted neighbourhood that offers a bakery, flower shop or a drugstore next to a supermarket is disliked.
- One big central park in the car restricted residential area is not preferred, although, there is some unobserved variance between this taste.
- Considering the socio-demographic variables, more person households do not prefer to walk several minutes to a car parking, while households with children between younger than 6 years old value walking to a car parking facility positively.
- People that use their car daily or use their car for private purposes only, do not prefer to move to a car restricted residential area.
- House purchasers are more likely to move to a car restricted residential area than house renters.
- There is no distinct attitude regarding car use, quality of the living environment or car restricted residential area that influences the preference for moving to a car restricted residential area.
- The design variables of car restricted residential areas have in comparison to the influence of household-composition, car use variables and house ownership arrangements a lower influence on the willingness to move to a car restricted residential area.

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8

Model application: predicting the willingness to move to a car restricted residential area

The insights gained by the interpretation of the model results are used to draft several designs of car restricted residential areas. The designs are used to gain an understanding of how each design variable influences the willingness to move to a car restricted residential area (Section 8.1). Furthermore, multiple versions of Dutch new development projects of a car restricted residential areas are used as examples to establish four designs of potential applications of car restricted residential areas; (1) a spacious urban district design, (2) a spacious suburban design, (3) a compact urban district design, and (4) a compact suburban design. Section 8.3 will discuss the results of the model application.

8.1 Changes in willingness to move due to design variations of a car restricted residential area

To gain an understanding of how each design variable influences the willingness to move to car restricted residential area, it is calculated what the effect of adjustments in the design of car restricted residential area is on the percentage of car owners willing to move to a car restricted residential area. The extent to which the percentage of car owners willing to move changes as a result of adjustments in attribute values is determined through direct elasticities (Koppelman & Bhat, 2006. P48) (see Appendix J for the calculation). For the influence of household size and the number of children between 0-5 years old in the household on how the walking time is perceived, the average population numbers are used. The same applies to the distribution of residence purchasers to residence renters. For the influence of current walking times and current parking arrangements on how the parking costs in a car restricted residential area are perceived, the distributions of the sample are used. This also applies to the distribution of people that use their car daily and use their car primarily for private purposes. Therefore, the contribution of these variables represents the average change in the percentage of car owners willing to move to a car restricted residential area. Figure 8.1 indicates per design variable the influence of changing the design considering this design variable on the percentage of car owners willing to move. Furthermore, the effect of the car usage and house ownership arrangements on the percentage of car owners willing to move to a car restricted residential area are included in the figure.

The design variables ‘public parking garage’, ‘mixed high and low-rise buildings’, ‘lively street scene with residents and trespassers’, ‘only a supermarket’ and ‘small parks spread throughout the neighbourhood’ do have a significant contribution to the percentage of car owners willing to move to a car restricted residential area. On the other hand, ‘walking time to the car parking facility’, a ‘private parking space in a parking garage’, ‘mainly low-rise building’, ‘hardly people on the street’, ‘a simple range of facilities’ and ‘one big central park’ seem to decrease the percentage of car owners willing to move to a car restricted residential area over moving to a conventional residential area.

Most importantly, each minute of walking time up to 9 minutes decreases the percentage of car owners willing to move to a car restricted settlement over a conventional settlement with on average 13,5%. Likewise, every increase of €25,- to the monthly parking costs up to €300,- will decrease the willingness with on average -1,1%.

Furthermore, a car restricted residential area will on average be 47,3% less appealing to car owners using their car on a daily base. The same applies to people that use their car primarily for private purposes, a car restricted residential area will on average be 26,5% less appealing to them. A car restricted residential area will furthermore be on average 23,7% less appealing to people that currently rent a residence, on the other hand, on average people that currently own a house are 33,1% more likely to move to a car restricted residential area.

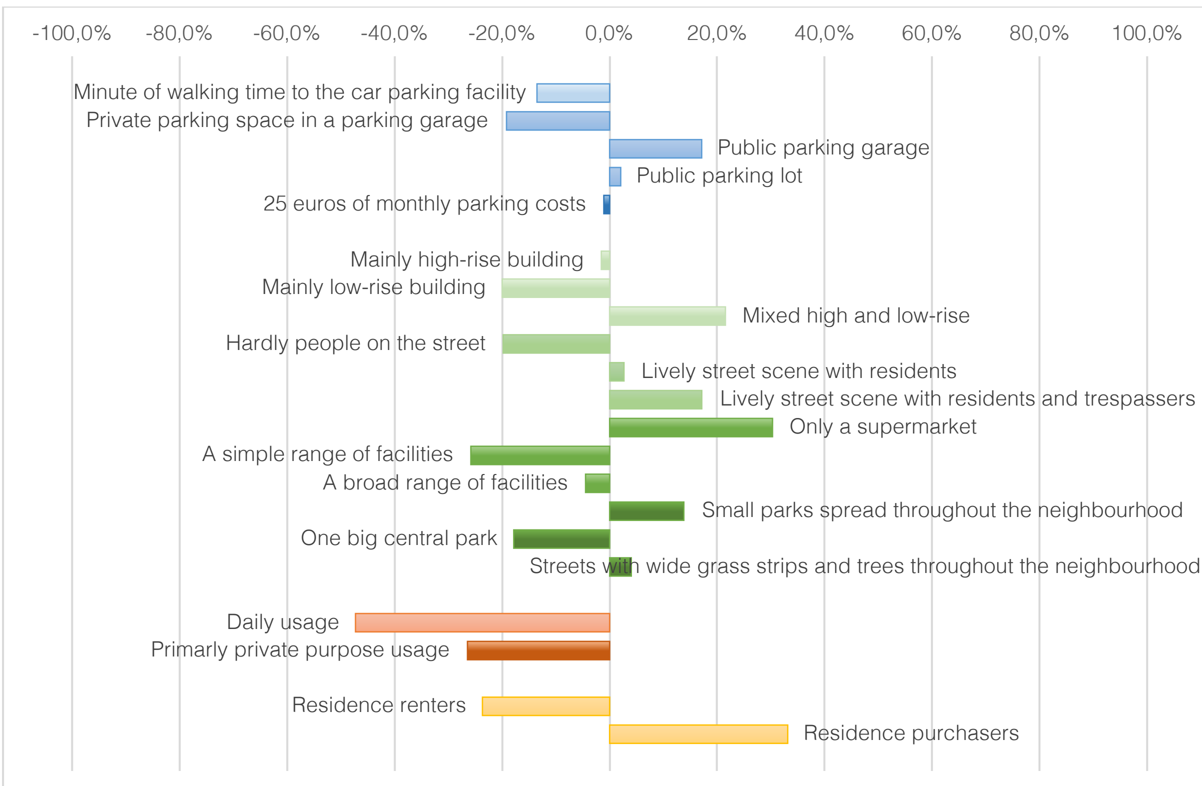

Figure 8.1: Extent to which the willingness to move to car restricted residential areas changes due to design variable level moderations

8.2 Car owners' willingness to move for various car restricted residential area designs

The understanding of the effects of design changes on car owners' willingness to move is used to draft multiple designs of car restricted residential areas. First, the designs with the lowest and highest level of attractiveness are presented, after which four potential cars restricted neighbourhood designs are outlined. These designs are drafted according to hypothetical examples of new development projects in several parts of the Netherlands. Potential physical design characteristics are drafted according to their characteristics, being **spacious** or **compactly** designed, or their locations, being in **urban** or **suburban**. The walking times to the car parking facilities and monthly car parking costs are variable since different locations in the Netherlands request different arrangements. The walking times to the car parking facilities are varied over four levels (1) *under every residential building* (0,5 min), (2) *at the* *head of the street* (3 min), (3) at an *approximately 500-metre distance from every home* (6 min) and (4) *at the periphery of the residential area* (9 min). By drafting different designs of car restricted residential areas, an understanding is gained of car owners' willingness to move to a car restricted residential area according to different designs and residential area types.

8.2.1 Residential area design with the lowest and the highest willingness to move

The combination of variables that have the least influence or negatively influence the willingness to move to a car restricted residential area is used for drafting the design with the lowest willingness to move. The design variables that seem to positively increase the willingness to move to a car restricted residential area together form the neighbourhood design with the highest willingness to move. For the percentage of car owners using their car daily and primarily for private purposes, the sample characteristics are assumed. For the distribution of residential renters and residential purchasers, the population averages are considered. These are in line with most newly developed projects that have a ratio of 40%-60% of rental-occupied and owner-occupied residences. The design with the potential lowest and highest car owners willing to move are presented in Table 8.1.

Table 8.1: Designs with the lowest and highest level of willingness to move

Design variable	Design with the lowest willingness to move	Design with the highest willingness to move
Walking time to the car parking facility	*9*	*0,5*
Type of car parking facility	*Private parking place in a parking garage*	*Public parking garage*
Monthly parking costs	*€300,-*	*€0,-*
Type of building	*Mainly low-rise building*	*Mixed high and low-rise*
The liveliness level	*Hardly people on the street*	*Lively street scene with residents and trespassers*
Facility level	*A simple range of facilities*	*Only a supermarket*
Green areas level	*One big central park*	*Small parks spread throughout the neighbourhood*
People using their car daily	*41,2%**	*41,2%**
People using their car primarily for private purposes	*44,7%**	*44,7%**
Residence renters	*41,5%***	*41,5%***
Resident purchasers	*58,5%***	*58,1%***
Willingness to move	0,8%	14,2%
* sample derivative **population average		

8.2.2 Residential area design 1: Spacious car restricted urban district

A car restricted residential area in an urban area that allows for a spacious design, would at first be characterised by a high level of green, as there is space reserved for streets with wide grass strips and trees throughout the neighbourhood. Moreover, the street scene is portrayed with a mixture of high and low-rise buildings. In this neighbourhood, several facilities can be found, such as small shops, coffee shops, restaurants, supermarkets, etc. As a result, some activity of residents can be found on the streets. Parking space can be arranged in-building at several distances from the residences and there is enough place to facilitate a private parking space for people who are interested. The parking costs are variable. The willingness of car owners to move to this type of residential area given this physical design variates between **2,0% and 4,3%** (see Table 8.2, Figure 8.3 and Appendix J).

Figure 8.2: Hypothetical illustration of a spacious car restricted district; Merwede Kanaal Zone Utrecht (Broekman & OKRA, n.d.)

Table 8.2: Characteristics of spacious urban car restricted district

Design variable	Design variable level
Walking time to the car parking facility	*Variable*
Type of car parking facility	*A private parking space in a parking garage*
Monthly parking costs	*Variable*
Type of building	*A mixture of high and low-rise buildings*
The liveliness level	*Lively street scene with residents*
Facility level	*A simple range of facilities*
Green areas level	*Streets with wide grass strips and trees throughout the neighbourhood*
People using their car daily	*41,2%**
People using their car primarily for private purposes	*44,7%**
Residence renters	*41,5%***
Resident purchasers	*58,5%***
Willingness to move	2,0% – 4,3%
* sample derivative **population average	

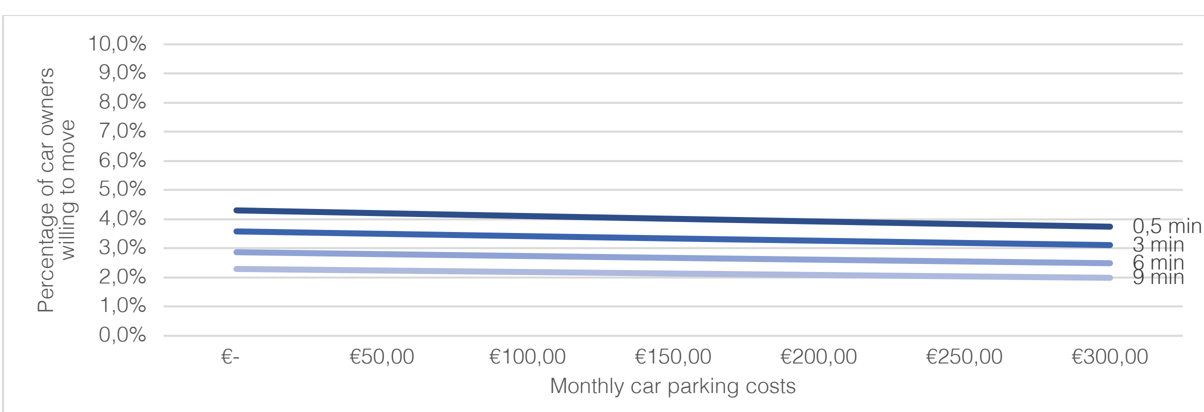

Figure 8.3: Percentage of car owners willing to move to a potential spacious urban car restricted district

8.2.3 Residential area design 2: Spacious car restricted suburb

A spaciously designed car restricted suburb is characterised by low-rise buildings and a lot of green space. There is plenty of space to fill streets with wide green grass strips and trees. Multiple car parking lots are at the head of the streets or the periphery of the neighbourhood, the walking times to the car parking facility, therefore, may vary. In most suburbs car parking costs will be very low, however, this may deviate between over different locations in the Netherlands. The neighbourhood is very quiet and only consists of a small supermarket, moreover, there is hardly any activity of residents on the streets. Considering car owners' willingness to move to these types of settlements, **2,3%** to **5,0%** is willing to move to a spacious car restricted suburb with these characteristics in comparison to a conventional neighbourhood (consult Table 8.3, Figure 8.5 and Appendix J for the percentages per design).

Figure 8.4: Hypothetical illustration of a spacious car restricted suburb; Bosrijk, Eindhoven (LPM Development, n.d.)

Table 8.3: Characteristics of spacious car restricted suburb

Design variable	Design variable level
Walking time to the car parking facility	*Variable*
Type of car parking facility	*Public parking lot*
Monthly parking costs	*Variable*
Type of building	*Mainly low-rise buildings*
The liveliness level	*Hardly people on the streets*
Facility level	*Only a supermarket*
Green areas level	*Streets with wide grass strips and trees throughout the neighbourhood*
People using their car daily	*41,2%**
People using their car primarily for private purposes	*44,7%**
Residence renters	*41,5%***
Resident purchasers	*58,5%***
Willingness to move	2,3% – 5,0%
* sample derivative **population average	

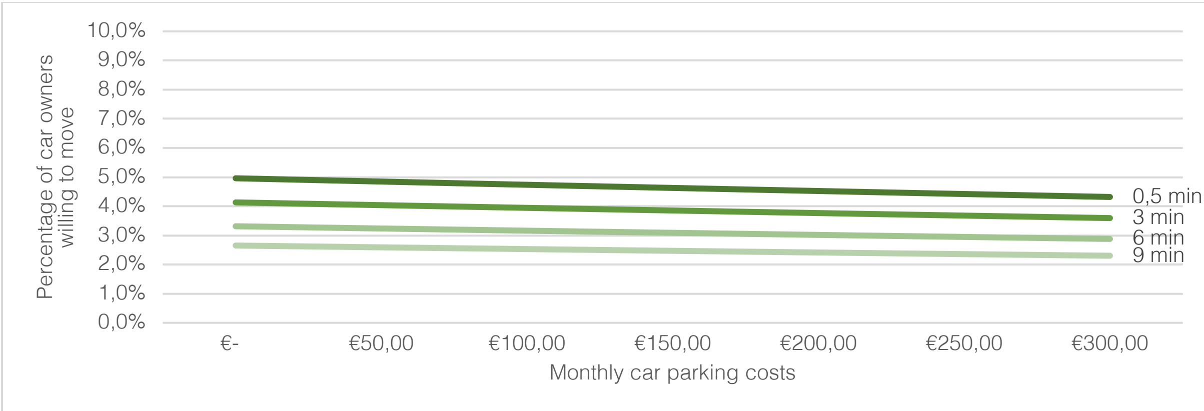

Figure 8.5: Percentage of car owners willing to move to a potential spacious car restricted suburb

8.2.4 Residential area design 3: Compact urban district

The design of a compact car restricted urban district is identified by mainly high-rise buildings. Despite the limited space one big park is included to provide the residential area with green space. The neighbourhood consists of a broad range of facilities and this attracts not only residents but also trespassers to the area. Accordingly, the streets in this area include a lot of activity. The car parking facilities can are clustered and established within buildings, but space can be reserved in every building to arrange car parking facilities within every occupants' buildings. As most of the car parking facilities are located in their residential buildings, the walk times to the car parking may vary between 0,5 minutes to maximum 9 minutes from their residence to their car. As the space in urban areas usually is scarce, parking a car comes at a price, and therefore parking a car may come at a price. Nevertheless, **2,7% to 5,7%** of car owners would prefer moving to a car restricted residential area with this design over moving to a conventional residential area (see Table 8.4, Figure 8.7 and Appendix J).

Figure 8.6: Hypothetical Sluisbuurt, Amsterdam (Ontwerpteam Sluisbuurt, 2017)

Table 8.4: Characteristics of compact urban car restricted district

Design variable	Design variable level
Walking time to the car parking facility	*Variable*
Type of car parking facility	*A public parking garage*
Monthly parking costs	*Variable*
Type of building	*Mainly high rise buildings*
The liveliness level	*Lively street scene with residents*
Facility level	*A broad range of facilities*
Green areas level	*One big central park*
People using their car daily	*41,2%**
People using their car primarily for private purposes	*44,7%**
Residence renters	*41,5%***
Resident purchasers	*58,5%***
Willingness to move	**2,7% – 5,7%**
* sample derivative **population average	

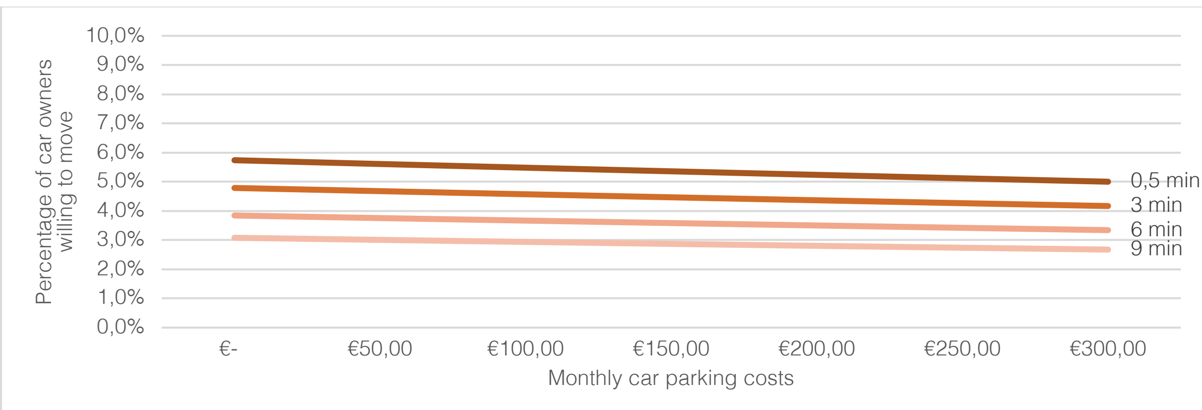

Figure 8.7: Percentage of car owners willing to move to a potential compact urban car restricted district

8.2.5 Residential area design 4: Compact car restricted suburb

The car parking facilities in the design of a compact car restricted suburb are clustered. In most cases, car parking facilities can be found at the tops of the residential streets, which means that it will take residents no longer than a couple of minutes to walk from their car to their residence. Car parking takes place off-street and is facilitated in-building. However, as the main aspect of the design is to be compact, there is limited space arranged for parking, furthermore, establishing car parking garages is costly, therefore parking a car in this residential area may come at a price, which may be varying according to the walking distance to the car parking facility. Furthermore, the design is portrayed by a mixture of low and high-rise buildings. Small parks can be found in several places in the neighbourhood and the streets are used by children to play outside and strolling residents. Lastly, the residential area consists of a simple range of facilities, which will facilitate people in not having to leave the neighbourhood for their daily needs. A car residential area with these specifics will be preferred by **3,3% - 7,0%** of car owners over a conventional residential area (consult Table 8.5, Figure 8.9 and Appendix J for the percentages of car owners that is willing to move per design).

Figure 8.8: Hooge Stenen Leidsche Rijn (DELVA Landscape Architecture & Urbanism, n.d.)

Table 8.5: Characteristics of a potential compact car restricted suburb

Design variable	Design variable level
Walking time to the car parking facility	*Variable*
Type of car parking facility	*A public parking garage*
Monthly parking costs	*Variable*
Type of building	*A mixture of high and low-rise buildings*
The liveliness level	*Lively street scene with residents*
Facility level	*A simple range of facilities*
Green areas level	*Small parks spread throughout the neighbourhood*
People using their car daily	*41,2%**
People using their car primarily for private purposes	*44,7%**
Residence renters	*41,5%***
Resident purchasers	*58,5%***
Willingness to move	3,3% – 7,0%
* sample derivative **population average	

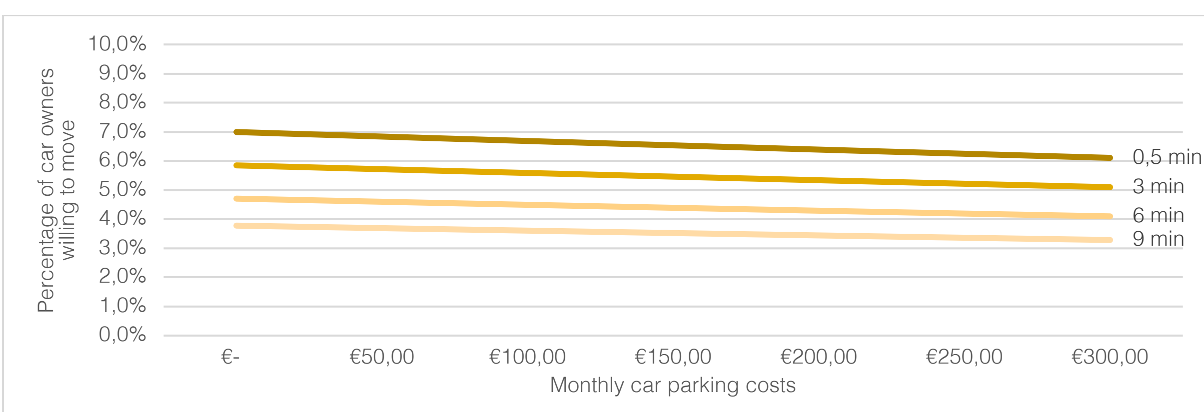

Figure 8.9: Percentage of car owners willing to move to a potential compact car restricted suburb

8.3 Conclusion

Overall, the walking time to and monthly price for parking significantly withhold to the willingness to move to a car restricted residential area, while the physical environment of a car restricted residential seems to be of less importance. Therefore the added value of enhancements to the physical environment that serve to compensate for walking time to the car parking facility may be limited. The utility derived from a physical characteristic stays the same, whereas the disutility perceived with walking time to the car increases with longer walking times. The effect of physical characteristics is to the willingness of car restricted residential aeras is static, and therefore with increasing walking times to the parking facility, to a smaller extent compensates for the linear increasing disutility perceived with longer walking times. Therefore the effect of an improvement to the physical environment of a car restricted residential area will decrease exponentially with longer walking times. This means that the locations of car parking facilities should be considered carefully as these significantly affect the willingness to move to a car restricted residential area.

A **compactly** designed car restricted residential area is more preferred over a **spaciously** designed car restricted residential area, even though a spacious designed area allows for introducing wide grass stripes and threes throughout every street. The limited space that is accompanied by a compactly designed car restricted residential area results in a call for in-building car parking facilities and may even only allow one big central park in the residential area, which both are highly valued by car owners. as a compact design does not facilitate private parking or mainly low-rise buildings and has the aspect of being livelier than suburbs. Furthermore, scarce public space is likely to contribute to introducing walking time to car parking and setting a parking price for parking in these areas, which will decrease the percentage of car owners willing to move to a car restricted residential area over a conventional residential area. Therefore, the **parking facility locations and the introduction of parking costs need to be considered carefully**. Furthermore, compactly designed residential areas are in most cases characterised by more activity of people on the streets.

The liveliness level also forms the biggest difference between designing **urban districts** and **suburbs**, as urban districts are often designed to accommodate more people. Depending on the location and amount of people this will require a simple or broad range of facilities. Although these are valued negatively, the offer of facilities is interrelated with the liveliness level of the residential area, which is valued positively. This implies the broader the range of facilities offered in a residential area, the more people will be attracted to the residential area which will contribute to the liveliness level of the area. Therefore, in the design of a car restricted residential neighbourhood, a **trade-off** should be made **between the range of facilities offered and the liveliness level** that is facilitated. Since only having a supermarket has the highest contribution to the willingness of car owners to move to a car restricted residential area over a conventional residential area, allowing only a supermarket may be preferred over a residential area design that introduces street activity its occupants and trespassers.

9

Conclusion & discussion

This chapter will contemplate the insights gained by this research (Section 9.1) and will discuss the implications of these insights for policymakers (Section 9.2). Lastly, the results of this study will be discussed and validated with current literature (Section 9.3).

9.1 Conclusion

There is a housing shortage in the Netherlands and the Dutch population keeps on growing. Meanwhile, the number of cars is increasing, while the total kilometres that are driven per year decreases. This indicates that most cars mainly are stationary. Especially in cities, this forms an issue, as public space is scarce and room for parking space directly competes with sidewalks, bicycle paths, playgrounds, green space or recreational facilities. Enhancing a city's growth, therefore, comes, in most cases, at the expense of the liveability and the accessibility of a city, due to cities becoming more and more silted up by cars. To overcome this, municipalities are aiming at introducing car restricted areas, among which the establishment of newly developed car restricted residential areas. Nevertheless, it is expected that car owners will not be in favour of living in a car restricted residential area as their design hampers residents to park near their residences. Even though, an advantage of not having cars portraying the neighbourhood's street scene, is that space originally used for cars and car infrastructure can be assigned to other functions. However, currently, a lack of information exists of how a car restricted residential area should be designed in terms of the physical environment in relation to car parking facilities. For municipalities, the question, therefore, remains how to design an attractive car restricted residential area for car owners. Hence, since this has not been studied before, this research, aimed to determine the willingness of car owners to move to a car restricted residential area, according to its parking facility arrangements and physical design characteristics. And thus aimed to answer the following research question:

What is the effect of parking arrangements and the physical environment of a car restricted residential area on car owners' willingness to move to a car restricted residential area over a conventional residential area?

First, it is determined which design characteristics of the car parking facility and physical design characteristics may relate to the willingness to move to a car restricted residential area. A car restricted area in this study is distinguished as a visually car-free area, in which access to vehicles is restricted and car parking is either provided in-building, underground or at the edge of the neighbourhood, however, there is no attempt to restrict car use or ownership in these neighbourhoods. The preferences regarding seven variables affecting the willingness to move to a car restricted residential area were measured: (1) walking time to the car, (2) type of car parking facility, (3) monthly parking costs, (4) type of building, (5) liveliness level, (6) amount of facilities, and (7) the degree of green areas. Accordingly, respondents were requested to indicate their preference for designs of car restricted residential areas and if they would consider moving to the residential area of their preference over a conventional residential area.

9.1.1 The effect of different design variables on the willingness to move to a car restricted residential area

The research results verify that car owners are not keen on walking several minutes to their car or pay for parking their car. A minute of walking time increase will almost exponentially decrease the percentage of car owners willing to move to a car restricted residential area. The locations of parking facilities, therefore, should be considered carefully. Furthermore, public parking facilities are more valued over private parking, which may allow reducing the total amount of surface used for car parking. The results point out that particularly public parking garages are favoured. Especially in car restricted residential areas parking garages offer a straightforward way to visually remove cars from the street scene.

People seem to dislike a neighbourhood in which only one big central park forms the green space included in the neighbourhood's design, or a neighbourhood in which there is a hardly any activity of people on the streets. The last is in contrast to the finding that a car restricted residential area consisting of only a supermarket is liked by car owners whereas there is an aversion with regard to a small range of facilities additional to a supermarket. This implies that the liveliness level and level of facilities offered in a car restricted residential area should be traded off, as more facilities would attract more people and will increase the liveliness level of the residential area and the other way around.

9.1.2 The relation between the distance to a car parking facility and the physical design variables of car restricted residential areas

As car owners negatively perceive the walking time to a car parking facility, it may be valuable to compensate for the distance to a car parking with certain physical design characteristics. However, it should be stated that the static utility that is received from improvements to the physical design, with increasing walking times to the parking facility, will to a smaller extent compensate for the linear increasing disutility perceived with longer walking times. Therefore the effect of an improvement to the physical environment of a car restricted residential area will decrease exponentially when with longer walking times. This indicates that the influence of improvements to the physical environment will be less significant as the area of development requires car parking facilities to be at the periphery of the residential area.

9.1.3 The effect of socio-demographic variables, car use, current residential environment, and attitudes on the willingness to move to a car restricted residential area

The results indicate that bigger households are willing to walk fewer minutes to their car. On the other hand, households with (multiple) children in the age category of 0 to 5 years old, prefer to have some minutes of walking time to the car parking facility. Car owners daily using their car and/or using their car for primarily private purposes are less keen on moving to a car restricted residential area. Lastly, it is observed that car owners currently parking close to their home or used to pay for car parking are willing to pay monthly for car parking in a car restricted residential area. Lastly, residence owners are, opposite to residence renters, more willing to live in a car restricted residential area. Which may indicate that people investing in a residence are more concerned about their residential environment than residence renters. Therefore, rental properties in car restricted residential areas may be less attractive to car owners.

9.1.4 Current attitudes of car owners towards a car restricted residential area

In terms of traffic safety, traffic nuisance, presence of footpaths, bicycle infrastructure and presence of green areas the expectations of car restricted residential areas are very high. Although literature argues the advantages of restricting vehicles, people do not perceive the traffic safety to be higher or the amount of traffic to be lower than in their current residential environment and only consider the degree of traffic nuisance to be less than in their current neighbourhood. As anticipated, people's expectations of the car parking availability and accessibility are lower compared to the current residential environment. Surprisingly, people expect that in these more pedestrian-oriented areas, the presence of facilities such as supermarkets, shops and catering is lower in car restricted residential areas than in there current residential areas. Nevertheless, these expectations of car restricted residential areas and attitudes towards car use or the quality of the living environment did not seem to influence the willingness to move to a car restricted residential area.

9.1.5 Willingness of car owners to move to a car restricted residential area over a conventional residential area

The willingness of car owners to move to a car restricted residential area is low and most people seem to prefer to live in a conventional residential area. Spaciously designed car restricted residential areas, characterised by higher levels of green space and lower levels of liveliness, appeared to be less appealing to car owners. Compact car restricted residential areas, however, seem to be a bit more in favour amongst car owners. This may be because of their higher levels of liveliness, higher contributions of high-buildings, and lower levels of green.

9.2 Implications for policymakers

For municipalities and project developers the results of this study provide valuable information in terms of the relative importance of attributes and their contribution to the willingness of car owners to move to a car restricted residential areas. The results, therefore, provide them with guidelines to the essential attributes for increasing the willingness of car owners to move to these type of areas.

Recommendation (1): Do not assign to much value to a car restricted residential area at least not in terms of the physical environment

Although developing car restricted residential areas may seem to be an effective measure to increase the liveability of an area, these types of residential areas may not be very attractive to car owners as only a **minority of car owners** reveal to be willing to move to a car restricted residential area over a conventional residential area (13,7% in the most beneficial case). The results indicate that car owners overall have a negative association with moving to a car restricted residential area and that the benefits to the physical environment of car restricted residential areas may, according to this research, not be appealing enough for car owners to be willing to move to a car restricted residential area.

Recommendation (2): Consider the locations of the car parking facilities carefully

The results indicate that car owners negatively perceive walking time to the car parking facility. This means that increased walking times to the car parking facility significantly decreases car owners' willingness to move to a car restricted residential area. Developing concentrated car parking facilities at a distance from residences, therefore, only **decreases the preference** for such neighbourhoods.

However, only households with **children younger than 6 years old** may perceive an increase walking distance to a car parking facility to be positive, which may be associated with the range in which their children are able to play safely on the streets. The second recommendation, therefore, is to carefully consider the locations of clustered car parking facilities and to adjust this to the target market for which the residential area is designed.

Recommendation (3): Only introduce car parking costs when necessary, as only a few will be willing and able to pay for car parking

Furthermore, the findings of this study show that most people are not willing to pay for car parking. Only people that currently walk 1 minute or less to their car or are already used to pay for parking their car are **willing to pay** for parking their car in a car restricted residential area. Higher parking prices, therefore, on average will have a negative effect on the willingness among car owners to move to a car restricted residential area.

Moreover, it has been indicated that although people were attracted to the design of the physical environment, not all were **able to pay** for parking a car and therefore were restrained in expressing their preference for moving to a car restricted residential area. Thus, introducing parking cost should be considered carefully, to prevent excluding the possibility of living in a car restricted residential area for some people. The suggestion, therefore, is to introduce car parking costs only when establishing car parking facilities is costly and therefore should be compensated by parking costs. Furthermore, it might be worthwhile to consider making the parking costs partially dependent on the income level of the households. By doing so, low-income households will not be put off by high parking costs. This is especially relevant since a percentage of residences in these newly developed residential areas is often reserved for social housing (DUIC, 2020; Gemeente Amsterdam, 2017).

For, real estate developers this finding is critical, as establishing car parking facilities underground or in-building is very costly. Therefore, other revenues should be introduced to efficiently operate the car parking facilities in these areas. It may therefore be considered to allow for both residential as non-residential use and introduce dual usage. This enables the possibility to rent out empty parking spots for non-residents like for example the RAI convention centre is doing (Mobypark, n.d.). This option may be valuable when employment or shopping facilities are close by.

Recommendation (4): Apply a car restricted residential area when in case of limited space a compact design is required

Especially in case of a compactly designed residential area the willingness to move to a car restricted residential area increases. Therefore the fourth recommendation is to apply a car restricted residential area in case a compact design is required. These designs may be more prefered due to their higher levels of liveliness, higher contributions of high-buildings, and lower levels of green. The physical environment of these neighbourhoods should preferably encompass a mixture of high and low-rise buildings, as a variety in buildings seemed to be preferred by car owners. Furthermore, small parks spread throughout the neighbourhood and the convenience of just a supermarket seems to sufficient, which may be due to the broad products that supermarkets nowadays offer. Lastly, when considering restricting traffic movements in residential areas, it is important to accompany this restriction of vehicles with a lively street scene and some small parks spread throughout the neighbourhoods.

Recommendation (5): It is not essential to facilitate private parking places

Results indicate that people disfavour a car restricted residential area with private parking facilities. On the other hand, it seems that car owners do value a public parking garage. Therefore it is suggested to only include public parking facilities in the design of a car restricted residential area. At the same time, this offers the possibility of dual usage, which implies using a parking facility not only for residents but also for a shopping centre or an office. Since most people (under normal circumstances) are not at home during the day, for example, employees of offices can use the parking space on the daytimes and residents during the night times. This, however, should fit in the design of the surrounding area of the newly developed neighbourhood, as this design should propose an offer of dual-use. The opportunity of dual-use may especially be valuable in urban areas where public space is often scarce. Furthermore, dual usage may not only optimise parking but may also increase the revenue as formerly discussed (see recommendation 3).

Recommendation (6): Establish an adaptive design of car parking facilities
Lastly, there is the possibility that the shift from car ownership to car-sharing accelerates. Therefore the design of the parking facilities in car restricted residential areas should be able to adapt to trends in car use. Especially since research indicated that introducing walking time to a car parking and living in a car restricted residential area, in some cases, can have a negative effect on car ownership (decrease) (Christiansen et al, 2017; Melia, 2014; Nobis, 2003; Scheurer, 2001). When car ownership of car owners living in car restricted residential areas does decrease, this will result in a reduced number of required parking places. The design of car parking facilities should, therefore, incorporate the flexibility to transform into a mobility hub or to be assigned to different functions, e.g. retail facilities.

9.3 Discussion of results

9.3.1 Preference considering design variables of the car restricted residential area

Walking time to the car parking facility
The results suggest that people negative value the walking time to the car parking facility. This implies that people are not in favour of walking several minutes to their car. This is in line to the results of the study of Borgers et al. (2008) that found when considering living in a car restricted residential area, people have a negative association with having to park from the residence. Even though Christiansen et al. (2017) observed that on average people are willing to walk 100 metres (approximately one minute) from their residence to their car. Their study found that walking time to the car has a negative effect on car ownership and car use and thus walking time is perceived negatively as well.

Car parking costs
Likewise, monthly car parking costs are not preferred by car owners. This is supported by the fact that in general people try to minimise their costs. Likewise, van der Waerden et al. (n.d.) have found that people only are willing to pay for parking in their residential area when a secured car parking is offered or this will increase the probability of a free space close to their residence. Antolín et al. (2018) have found that especially residents perceive parking costs and walking times to car parking facilities worse that non-residents, implying that on average residents do not favour walking to or paying for car parking facilities. Furthermore, a literature review performed by Parmar et al. (2020) shows that for residents out-vehicle costs such as parking costs and walking time to the car parking are more important than in-vehicle costs, such as the fuel costs and travel time.

Public garage
Furthermore, the favour for a public garage and the disfavour for a private parking space in a parking garage, on the other hand, was not anticipated. As it was expected that people would prefer a private parking space in a parking garage over a public parking garage. However, this may be the result of psychological factors, since the study of Parmar et al. (2020) indicated that the difference between public and private parking space is not important to people, as long as they are convenient and safe. Furthermore, Guo (Guo, 2013b) has found that while households own a private garage, they still often prefer parking on-street. This provides clarification for people's evaluation of private car parking facilities.

Facilities
Only having a supermarket in the neighbourhood was not expected to be favoured, as it was assumed that having more facilities in the neighbourhood would enhance residents' daily life in a car restricted neighbourhood. This expectation was in line with the findings of McCormack et al. (2019) and Brookfield (2016) that observed local facilities to be an important factor in people's residential choice. Especially in car restricted residential areas, the presence of various facilities offering multiple services was found to be important in fulfilling it's residents' preferences and needs (Carse et al., 2013; Cervero & Radisch, 1996; Jacobs, 1993; Loo, 2018; Schwanen & Mokhtarian, 2005b). This preference may be related to the expectation of respondents of the presence of facilities such as supermarket, shops, and catering to be lower in a car restricted residential area compared to their current residential area. Yet, several studies state that having supermarkets on walkable distances from residences is found to be a most important aspect for residents in walkable cities such as car restricted residential areas (Sinniah et al., 2016; Perrotta et al., 2012).

Green areas
Considering green areas, a car restricted residential area consisting of only a central park is valued negatively. Zhang et al. (2017) studied the influence of quality and quantity of green areas in neighbourhoods on neighbourhood satisfaction. They have found that the accessibility and usability of green spaces are more important than the dimension of green areas. This may indicate that people's association with one big central park in the neighbourhood is negative as the degree of accessibility of the green area in the neighbourhood is lower compared to multiple green parks throughout the neighbourhood or grass strips and trees in every street.

9.3.2 Willingness to move to a car restricted residential area

The results of this research indicate that for different designs of car restricted residential areas on average 3,0% of the car owners would choose to move to a car restricted residential area over a conventional residential area. This differs from the results of Gundlach et al. (2018) finding that 60% of their respondents would choose to live in a car restricted residential area and improvements to bicycle infrastructure could even increase this percentage to 90%. In this research, the car restricted neighbourhood design with the highest willingness to move would only result in 13,7% of car owners preferring a car restricted residential area over a conventional residential area. Therefore, the willingness to move levels found in this study may seem fairly low. However, it should be stated that only 20% of the respondents in the research of Gundlach et al. (2018) owned a car, and therefore may be more appealed to living in a car restricted residential environment. Moreover, their research also observed that car owners were less likely to move to a car restricted residential area.

Considering the finding that the willingness to move to a car restricted residential area is slightly higher than a conventional residential area in compactly designed neighbourhoods, Mouratidis (2018) found that residents of compact-cities derive more value to the physical environment of their neighbourhoods in terms of safety, the existence of parks and squares, limited noise, traffic and litter. They found that especially in compact cities enhancements to the physical environment contribute to a more liveable environment. This may explain the slight increase to the willingness of car owners to move to a car restricted residential area compared to conventional residential areas in compact urban districts and compact suburbs. Furthermore, more than half of the sample indicated to live in Amsterdam, Rotterdam, The Hague or Utrecht, and a high percentage of the sample stated to live in the city centre or off-city centre. This implies that most residents currently live in a compact residential area, which may have resulted in a high willingness to move to car restricted residential area with a compact design.

Moreover, it should be stated that the willingness to move to a car restricted residential area is furthermore interrelated to the supply of residences in non-car-restricted residential areas. This is also supported by various researches that state that the available number of alternatives indicate the freedom people have in the selection process. Thereby, the supply of residences in conventional residential areas may influence the willingness to move to a car restricted residential area (Borgers et al., 2008; De Vos et al., 2012; Lin et al., 2017; Molin & Timmermans, 2010). Even though there currently is a housing shortage, the residences offered still are located in conventional residential areas, which may influence the choice behaviour of car owners.

Furthermore, this research was not able to assess whether the observations by this research are generalisable outside the Netherlands. This is uncertain because it is unknown to what extent the willingness to move to car restricted residential areas among Dutch car owners differ from foreigners. For example, the findings of Gundlach et al. (2018), stating that if bicycle infrastructure is enhanced, the preference for a car restricted residential area in Berlin would increase with 30%. However, as in the Netherlands, the quality of bicycle infrastructure in most newly developed residential areas is already fairly high, therefore this influence on the willingness to move to a car restricted residential area may be less in the Netherlands. So in case, the urban design standards are different between countries, the preference for the car parking arrangements and physical design variables, as the willingness to move to a car restricted residential area may differ as well.

Influence of socio-demographic variables

The results of this research suggest that more person households have a negative association with walking time to car parking facilities and that, on the other hand, households with children younger than 6 years old are willing to accept longer walking times to the car parking facility. This is in contrast to the findings of Christiansen et al. (2017) that have found that people with young children are less willing to accept longer distances to residential car parking facilities. They have found that younger people and people that live in apartment buildings are willing to walk further to residential car parking facilities, whereas, people with young children and people who already have good access to car parking are less keen on walking to their parked car. Yet, the positive association of walking time to the car parking of households with younger children found in this study may be related to the range in which their children can play safely outside. Which has been found to be an important advantage of living in a car restricted residential area by its residents (Scheurer, 2001; Nuetzel, 1993; Clayden et al., 2006; Melia, 2009).

Influence of car use

Furthermore, it seems that car owners daily using their car and/or using their car for primarily private purposes are less keen on moving to a car restricted residential area. This may be supported by the conclusion of Guo (2013a), noting that the supply of parking facilities does influence the car use and car ownership of households. The study found that residents that are offered car parking close to their homes possess more cars, employ more car trips and drive longer distances. Therefore the car parking arrangements and car restrictions in car restricted residential areas may be less appealing to people using their car frequently.

Furthermore, this study observed that car owners currently parking their car at a walking distance of 1 minute or less, currently pay periodically for parking their car in their neighbourhood or lastly bought a car parking spot are willing to pay monthly for car parking in a car restricted residential area. Guo and McDonnell (2013) support these findings and have found that people that currently pay for car parking are willing to pay more for residential car parking for car parking in hypothetic residential areas.

Influence of house ownership

Even though Stubbs (2002) concluded that the proximity of car parking to occupants' residences is one of the most important aspects of designing car parking facilities in residential areas and residence occupiers appear to be less likely to purchase a house if the car parking arrangements are not fulfilling, still this study indicates that residence owners are, opposite to residence renters, more willing to live in a car restricted residential area. Which may imply that people investing in a residence are more concerned about their residential environment than residence renters. This is supported by the study of Groote, et al. (2017) that note that the residential environment reflects the investment potential of the residence.

Influence of attitudes

Furthermore, it was expected that ideologies and habits would strongly influence the preference for living in a car restricted residential area. Especially as there is high heterogeneity in the average willingness to move to a car restricted residential area, meaning that people have different associations with living in a car restricted residential area. However, attitudes regarding car use and quality of the living environment and expectations of car restricted residential areas did not seem to influence the preference to move to a car restricted residential area. Likewise, Ettema and Nieuwenhuis (2017) found that attitudes towards travel modes and residential location choice are to a limited extend related. It is assumed that people have unobserved associations with the concept of a car restricted neighbourhood, which may be resulting from the emotional preferences people may associate with living in a car restricted residential area. Indicated in Figure 3.1, these preferences may be resulting from rational preferences based on objective criteria.

Besides, many researchers studied the interrelations between residential choice behaviour, travel behaviour, built environment and travel mode attitudes and suggest that not only attitudes influence people's behaviour, but this effect may also work the other way around as well. Nevertheless, only a few studies provide strong empirical evidence on this discussion. Among which a study of Bothe (2010) which concludes that travel behaviour and built environment characteristics have a stronger effect on travel-related attitudes than the other way around. This is supported by a study of Kroesen et al. (2017) indicating that travel behaviour affects travel mode attitudes to a greater extent than vice versa. These findings may clarify the non-significant effect of attitudes on residential choice behaviour found in this study.

10

Reflection & Recommendation

In the last chapter, the research will be reflected in terms of data collection, data estimation and data interpretation, and accordingly to the identified limitations recommendations are provided for future research (Section 10.1). Lastly, the content of this paper will be considered from a practical and academic perspective, whereby the societal and scientific contribution of the insights provided by this research will be reflected (Section 10.2).

10.1 Reflection of the research and recommendations for future research

10.1.1 Reflection on and recommendations for data collection

Effectiveness of mailbox pamphlets

In a time where people could not be approached physically due to COVID-19, it was chosen to distribute pamphlets in residences' mailboxes. Since there were a lot of people working from home this turned out to be an effective way of approaching respondents, as the success rate of the 5000 distributed pamphlets was 4,9%. This experience was supported by several respondents that have left positive messages at the end of the survey. Yet, the first pressure of pamphlets did not include my name at the end of the research introduction and therefore it may be that fewer people responded to the pamphlet.

Influence of selection bias

Since questions are asked online and through mailbox pamphlets, there is the possibility of selection bias. Although it was tried to disperse the pamphlets in neighbourhoods with different designs and characteristics and different towns and cities in the Netherlands, it should be stated that due to the researcher selecting the neighbourhoods for spreading pamphlets into mailboxes introduces a selection bias. Furthermore, there is the possibility of self-selection by respondents, as people who highly value their car or their living environment could be more inclined to fill in the survey and express their (strong) opinion about a car restricted residential area. This means that the selection of respondents may not be properly random, and the risk that the sample obtained is unrepresentative for the population.

Risk of handing out a respondent reward

The lottery of the gift voucher that was associated with filling in the survey may have caused that people did not take full effort to fill in the survey. Although this risk is encapsulated by checking the minimum time that respondents took to fill in the survey, there is a possibility that people did not pay proper attention to the choice experiment. This may include not reading the introduction to the choice experiment and the attribute explanations carefully. Furthermore, it was checked whether people filled in the same answer in each choice set, however, this so-called non-trading behaviour was not observed.

Selection of attitudinal statements

Filling in a stated choice experiment is already fairly complicated, hence to prevent the survey from becoming even more complex, the number of attitudinal statements that was included was limited. The ultimate selection of statements may have been more categorised at forehand, thereby ensuring to measure multiple attitudes. Which might have resulted in finding significant attitudes that affect the willingness to move to a car restricted residential area.

The distinction between people's current residential area and the characteristics and a car restricted residential area

The main advantage of the stated choice approach is that public preferences can be observed by asking people to select the alternative that they prefer the most. This task is perceived to be common to people, as people do this, although unaware, throughout the day. This provides the opportunity to introduce new concepts and present hypothetical alternatives. However, there is a possibility that people are rather unfamiliar with the designs of the car restricted residential areas that were presented to respondents. Since it was not specifically asked what the physical environment of the respondents' current residential area characterised it is not known to what degree the presented designs of car restricted residential areas differ from the neighbourhood design in which they currently live. One respondent stated to live on a farm in a rural area, and therefore the presented residential areas are not comparable to the preferences of this respondent. Although it was tried to obtain information about the current residential environments of respondents, the questions providing this information, however, were not adequate. This was resulting from the attempt to limit the length of the survey. Accordingly, a simplified version of questions about the characteristics of a respondent's current neighbourhood was asked, presenting respondents with questions about how many minutes it took to reach several facilities from their home. However, this was insufficient to provide an indication of what degree the alternatives match the current residential environments of respondents, therefore, it is not possible to determine the effect of the distinction between the characteristics of residential areas on the choice behaviour. Furthermore, it simply may be that the identity of car restricted residential areas (both or either identity of a place or people's place identity as discussed in Section 3.1) does not correspond with location or personal preferences of persons.

Recommendation for future research (1): Identify respondents' reference level to presented alternatives

In order to understand the choice behaviour of respondents, it may be important to identify the reference framework of respondents. For example: even though Borgers et al. (2008) did not study the effect of building type in the residential area on the preference for a car restricted residential area, they did know in which type of building environment their respondents currently lived. Therefore, it is recommended to include questions in the survey that measure the reference framework of respondents considering the measured attributes in the choice experiment. In this way, the influence of the quality of the attribute in the respondents' current living environment may be measured.

Risk of hypothetical bias

The stated preference method assumes that the choice behaviour of people in the choice experiment is a good representation of their choice behaviour in the real world, implying that the preferences expressed by the respondents in the choice experiment are valid representations of their preferences in reality (Wardman, 1998). However, there is the possibility of people either not fully understanding the description of a car restricted residential area, or the design variables, or not able to oversee the implications of their choice. On the other hand, the validity of the analysis of the choice behaviour will also be affected by the relevance or actuality of the research topic and by respondents' incentive to take part in the research. In the past months, multiple municipalities introduced car restricted areas, which may cause people to have stronger opinions about car restrictions in residential areas.

10.1.2 Reflection on and recommendations for the data estimation method

Inclusion of statements in the choice model

The statements were included in the choice model by determining latent attitudes through exploratory factor analysis. The summated scales of individuals on these latent variables were included in the discrete choice models as variables. Nevertheless, the determination of latent attitudes through factor analysis is perceived to be inefficient since the actual choice behaviour of respondents is not considered in determining the latent attitudes (Kim et al., 2014). As a result, the latent variables in the choice model only measure the latent attributes and the utility, but not the effect on individuals' trade-offs itself, which means that the latent variables are perceived to have an alternative specific influence and therefore not allowed to be heterogeneous among individuals.

> *Recommendation for future research (2): Establish a hybrid choice model to compare the results and determine the influence of including attitudes to the model*
>
> In comparison to including latent variables as a result of factor analysis, a hybrid choice model includes attitudes as latent variables, being functions of the statements that were used to indicate the attitude. Thereby a hybrid choice model measures the effect of latent variables on individuals' trade-offs. A hybrid choice model may, therefore, provide a better understanding of the choice behaviour of respondents (Kim et al., 2014). However, as previously discussed, attitudes may not be a good predictor for behaviour and therefore one should not assign too much value to the value-added by estimating a hybrid choice model. Nevertheless, to verify the results of this study the results of a hybrid choice model and the willingness of car owners to move determined for several residential area designs can be compared to determine if the inclusion of attitudes in the model estimation influences the results.

Attributes did not fully resemble the respondent's needs

Some respondents indicated that the design variables used in the choice experiment did not fully reflect their needs and preferences when looking for a new residential environment. People stated that they missed the presence of public transport options, bicycle infrastructure, car-sharing options or playgrounds in the designs of the residential areas. However, the selection of attributes was made deliberately, to prevent the choice tasks for becoming to complex. Conventional conjoint models are only suitable to estimate a limited number of attributes, as a large number of attributes would require including a large number of profiles to still be able to estimate the model. For this reason, conventional conjoint models, as used in this study, might not be very useful for estimating residential preferences since many additional variables influence the valuation of a housing alternative. Support for this statement might be found in the Rho-square value of 0,265 of the ultimate model, indicating that only 26,5% of the choice behaviour of respondents could be explained by the model.

Recommendation for future research (3): Develop an integrated conjoint choice model

To fully resemble the residential choice behaviour of people an integrated conjoint choice model should be developed. Hierarchical Integration Information (HII) facilitates reducing the number of choice sets while maintaining the opportunity of including parameters for relevant attributes to the utility function (Oppewal, Louviere, & Timmermans, 1994). When applying this method, attributes are split into subsets of attributes that represent a decision construct. In this case, constructs for the physical environment, transport options and the relative location of the residential area could be drafted. Each construct will be measured in a different experiment by a subset of attributes. For every profile that is presented to the respondent, the respondent is asked to provide a rating. Accordingly, a bridging experiment is conducted in which these ratings are used as attributes. All sub-experiments can be analysed separately, and their results can be combined by substituting the parameters of the bridging experiment (Van De Vyvere et al., 1998). Thus an HII method requires developing two experiments, first, a rating experiment to predict preferences regarding attributes of constructs, subsequently a choice experiment to determine the trade-offs between the constructs evaluations.

10.1.3 Reflection on and recommendations for data interpretation

Car owners' association with car restricted residential area

First, it has been found that there is an average dislike for moving to a car restricted residential area. However, results indicate that people are very heterogeneous in there favour or disfavour for moving to a car restricted residential area. Therefore, it seems that some people have a positive image of a car restricted residential area, that could not be captured by the variables measured in the questionnaire and accordingly the model. Moreover, this positive image may influence the unobserved preference to move to a car restricted residential as well. The same applies to the aversion towards moving to a car restricted residential area. An attempt has been made to set up interviews with the respondents to understand their reasoning behind their choices. This question was asked when sending a mail with the lottery result and the questionnaire results. However, most attempts were left unanswered. Only replies from people that worked for municipalities were received, yet these answers were not considered to be useful for determining the reasoning behind people's trade-offs, as their opinion is probably very progressive and therefore not a good representation for the reasoning of the population.

Recommendation for future research (4): Conduct a supplementary qualitative research

Therefore it is recommended for future research to include a question at the end of the survey to set up an opportunity for an interview for people that are interested in the results and like to discuss some results. These interviews may be used as qualitative research supplementary to the choice experiment and provide a deeper understanding of the motive behind the preferences that are observed through the model estimation. Additionally focus groups may, next to the interviews, be used to discuss the different design variables of the car restricted residential areas and to understand why car owners favour certain design variables over others. Car owners of several parts of the Netherlands may be interviewed to observe if there are differences between the reasoning behind preferences of people living in various residential environments. These insights can be used to further adapt the design of a car restricted residential area in different residential environments to the preferences of car owners.

Unrepresentativeness sample
The sample was compared to the population not representative of the characteristics of age, educational level and household income level. Furthermore, the distributions of people living in a G4 city and more person households were higher than in the population. These deviations may be the result of the formerly described limitation of the selection process, which may have resulted in a non-random sample selection of the population. These deviations may also have affected the outcome of this study.

> *Recommendation for future research (5): Rerun the stated choice experiment with a new sample*
> Distributing the survey and approaching the respondents in another way may reduce the validity of the model. Therefore rerunning the stated choice experiment with a new sample may reveal if preferences considering design variables or the willingness to move to a car restricted residential area differs for another sample.

10.2 Reflection on the contribution of the research

10.2.1 Reflection on the societal contribution

Since municipalities currently are either considering the development of car restricted residential areas or already developing these areas, this research provides the first insights into the preference among car owners for car restricted residential areas. The finding that these residential areas are not particularly preferred by car owners over conventional residential areas is essential to project developers, as this increases the risk of vacancies. The knowledge gained by this research furthermore provides the first guidelines for designing a car restricted residential area in terms of car parking facilities and physical environment characteristics. Especially the finding of people not liking walking times to a car parking facility in these types of residential areas may form important information when considering the introduction of mobility hubs in residential areas, offering multiple transport sharing systems. This finding may be very critical in the feasibility of these hubs and should be considered for the implementation of these hubs, specifically, since urban developers are assigned a lot of value to these hubs and highly focus on the incorporation of mobility hubs in newly developed residential areas. Furthermore, the finding that most car owners do not prefer to pay for car parking may be critical for real estate developers, as realising car parking facilities underground or in-building is very costly, which may highlight the need to introduce other revenue streams which may allow reducing the parking costs for residents. Lastly, the findings suggest that car restricted residential area are, opposite to residence renters, more appealing to people that own a residence. Which may induce the risk of vacancies.

10.2.2 Reflection on the scientific contribution

Among the studies that observed the willingness to live in a car restricted residential area, this research was, to the author's knowledge, first to research the trade-off between parking arrangements and the physical design characteristics of car restricted residential areas. Therefore, this study extends and builds upon the knowledge about the design of car restricted residential areas. Not only did the research investigate car owners' preferences considering several design variables, but also the willingness to move to a car restricted residential area contingent on the design of the residential area was scrutinized.

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A

Appendix: Scientific article

Car owners' willingness to reside in a car restricted residential area

A stated choice experiment to assess the effect of parking arrangements and the physical environment on the willingness of car owners to move to a car restricted residential area

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A R T I C L E I N F O

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A B S T R A C T

This study's objective is to assess the effect of parking arrangements and the physical environment of a car restricted residential area on car owners' willingness to move to a car restricted residential area compared to a conventional residential area. A car restricted area in this study is distinguished as a visually car-free area, in which access to vehicles is restricted and car parking is either provided in-building, underground or at the edge of the neighbourhood, but there is no attempt to restrict car use or ownership. The preferences regarding seven variables affecting car restricted residential choice were studied: (1) walking time to the car, (2) type of car parking facility, (3) monthly parking costs, (4) type of building, (5) liveliness level, (6) amount of facilities, and (7) the degree of green areas. A stated preference (SP) survey was used to determine which characteristics affect this preference, and to what extent. The results indicate that only a few car owners are willing to move to a car restricted residential area over a conventional residential area. Overall, the walking time to car parking significantly harms to the willingness to move to a car restricted residential area, while the physical environment of a car restricted residential seems to be of less importance. This implies that the physical environment is only to a limitate extent able to compensate for distant car parking in these residential areas. However, future research may increase the understanding into car owners' willingness to move to a car restricted residential area by scrutinising people's underlying association towards car restricted residential areas.

1. Introduction

Even though the Dutch average car driving distance per year is decreasing, car ownership in the Netherlands is increasing (CBS, 2019). Especially in cities, this forms an issue, as public space is scarce and room for parking space directly competes with sidewalks, bicycle paths, playgrounds, green areas, or recreational facilities. Meanwhile, the Dutch population maintains increasing, while there is already a housing shortage (Rijksoverheid, n.d.). Accordingly, municipalities are facing the issue of expanding their cities when public space is already scarce (Melchers, 2018; Van Oort & Van Haaren, 2019). When developing conventional residential areas, establishing infrastructure for both driving and parked vehicles is very land-intensive (Marsden, 2014). This means that further infiltrating cities in the way we are used to will conflict with public space, or, in case of, rural areas with nature and agricultural land. Therefore, building more residential areas while facilitating car parking in front of residences will be at the expense of the liveability and accessibility of the Dutch living environment. For this reason, a policy shift can be observed to restricting cars in (areas of) the city, which means that space which is normally assigned to car infrastructure can be used for other functions. Car restricted residential areas are therefore perceived as an instrument to create more liveable and pedestrian-oriented cities including more public and recreational space (Scheurer, 2001). Living in a car restricted residential area will, therefore, mean not being able to park in front of a home, yet this will be compensated with enhancements to public and recreational space.

The prospect of not being able to park near residences, however, faces both resistance as support from political parties in a municipality and their residences (Redactie Rotterdam, n.d.; van Eijck & Naafs, 2019). In particular, real estate developers are afraid that there is a low demand for residences in car restricted neighbourhoods. To assess the influence of vehicle restrictions on the preference for a car restricted residential area, Borgers et al. (2008) researched how people can be compensated for parking remotely from their residences. Their study found that an important condition for introducing remote car parking is that the parking facility should be safe and that public transport facilities should be improved. Nevertheless, people prefer parking their cars adjacent to their residence. Additionally, Borges and Goldner (2015) studied the socio-demographic characteristics that are related to the willingness to live in a car-free neighbourhood. Their research observed that mainly younger people, households with children and people that frequently use a bicycle or walk are more willing to move to a car restricted residential area. Lastly, Gundlach et al. (2018) found in their research determining the willingness to live in a car restricted residential area that the overall willingness to live in a car restricted residential area is high. Nevertheless, important conditions to the attractiveness of these neighbourhoods are that the public transport fee should be reduced, bicycle infrastructure should be improved and streets should be dedicated to recreational areas.

Thus, so far, there is no insight yet on how the physical environment should be designed to compensate for remote parking. Moreover, researching car owners' preference for physical design characteristics of the living environment and parking facility arrangements in car restricted residential areas, will allow determining car owners' interest in moving to a car restricted residential area over a conventional residential area. The understanding of these preferences and the interest in car restricted residential areas among car owners would support the design and development of car restricted residential areas. This research, therefore, aims to assess the effect of car parking arrangements and the physical environment of a car restricted residential area on the expected interest of car owners for a car restricted residential area compared to a conventional residential area.

2. Literature review

Crawford (2000) was first to theoretically construe a car-free city. He illustrated a car-free city as a city in which lifestyles and city aspects such as streets, public space, civil buildings, dwellings, passengers' transport and freight logistics are arranged to be people-centric and to enhance urban life rather than facilitating cars' functioning. In the following years, the term car-free (residential) area was broadly used in literature. The terminology is introduced to address the efforts of local governments to enhance the attractiveness of their city (areas) by setting restrictions for active and stationary cars (Melia, 2014). Contingent on the physical size of the restrictions, these areas can be referred to as 'car-free cities', 'car-free districts', 'or car-free zones' (Loo, 2018). However, in most cases, there are exceptions to the restricted access, since public vehicles such as emergency services or delivery vehicles are generally not denied access to these areas (Gundlach et al., 2018; Nieuwenhuijsen & Khreis, 2016).

Car-free residential areas could be areas in which cars have to be parked at the periphery of the settlement. On top of that, residents could be contractually bound not to own a car and alternatively are provided with car-sharing vehicles at the area's boundary (Coates, 2013; Melia, 2009; Ornetzeder et al., 2008). Alternatively, 'car-free' may refer to 'car-less', which indicates not adopting a car in the daily lifestyle, thereby being 'free' from the car (Brown, 2017). Contrarily, it is argued that since the introduction of cars, cars have become an essential part of present-day cities and many people's life. For this reason, the term 'car-free' can be used not to indicate residents living completely without owning or using cars, however just not parking at or near home. Nonetheless, for allowing this 'parking at distance' a 'city of short walks' should be provided, referring to a city where almost all services required by residents are within walking distance Minh (2016). Currently, car restricted residential areas could be categorised into three categories (Morris, et al., 2009): (1) Visually car-free: access to motorised vehicles is restrained, but it is not sought to restrict or limit car ownership. Generally, parking is either established underground, in-building or at the periphery of the residential area. (2) Low-car: the overall parking standard is reduced. (3) Car-free: minor or no arrangements have been developed for vehicle infrastructure or residential parking.

The car-free character comes with several benefits enhancing the residential area's attractiveness. Considering the factors affecting the choice to live in a car restricted residential area, most researches study only the influence of objective factors, such as affordability and accessibility on people's residential location choice behaviour. This implies that residential choice is solely based on objective criteria (Kim, Pagliara, & Preston, 2005). However, others state that next to rational motives, also irrational motives influence residential choice (Levy, Murphy, & Lee, 2008; Munro, 1995). By interviewing real estate agents, Levy & Lee (2011) identified that residential location choice is based on three kinds of preferences: (1) property-specific preferences, (2) location preferences and (3) personal preferences. These three are all composed of rational and irrational (social-psychological) variables.

One of the most distinctive aspects of car restricted residential area is the constraint regarding vehicular access. Hence, parking arrangements have to be set for people using cars (Loo, 2018). Vehicular access should be controlled and the consequence of adjacent neighbourhoods being overflowed by parked cars of people living in the car restricted settlement should be overseen (Antonson et al., 2017; Melia, 2009; Scheurer, 2001). Furthermore, the proximity and security of the parking facilities should be considered, as people are less likely to purchase a residence when the parking provided is not satisfying their needs (Stubbs, 2002). It has been found that people fear car vandalism when parking remotely, therefore parking facilities on the periphery should be provided of proper security to compensate for having to park from home (Balcome & York, 1993; Borgers et al., 2008). Considering the willingness to park remotely, de Groote et al. (2015) have found that (higher) prices for car parking would increase the willingness to park a car at distance or even discard a car.

Since car owners may be hesitant about the car restrictions, it is essential that the physical design of a car restricted residential area is attractive. In this case, car owners' drive to change is essential for the application of novelties and radical behavioural change (Banister, 2008; Nieuwenhuijsen & Khreis, 2016). For this reason, other aspects should be emphasised that allow residents to fulfil their needs despite the neighbourhood's car restrictions (Loo, 2018). Hence, it is argued that in car restricted residential areas space which was normally used for car infrastructure should be assigned to the establishment of recreational areas (Loo & Chow, 2006). Dedicating streets to recreational areas would improve the incentive to move to a car restricted settlement (Gundlach et al., 2018). This will not only make the area more attractive but most importantly will increase the acceptance of the car restrictions by the public, thereby making the incentive to move to the area more feasible (Nieuwenhuijsen & Khreis, 2016).

Rydingen et al. (2017) state that developing a residential area completely free of vehicles is not feasible. This is due to residences still requiring to be accessible to people with disabilities and vehicles delivering heavy goods, which in the end constitutes to traffic as well (Rydningen et al., 2017). Especially when a low level of car use is supported access to public transport needs to be facilitated (Borgers et al., 2008; Gundlach et al., 2018; Loo, 2018; Melia, 2009; Scheurer, 2001; Topp & Pharoah, 1994). Additionally, it may be essential to substitute vehicle infrastructure with walking and cyclist infrastructure to increase the willingness to live in a car restricted residential area (Gundlach et al., 2018). To support a residential area with fewer traffic movements, it is argued that the residential area should be designed pedestrian-friendly (Loo & Chow, 2006; Minh, 2016). Therefore, the settlement should reflect residents' needs such as work, education, daily- and social needs (Loo, 2018). Preferably, the area should be designed as a fine grid area serving diverse purposes and offering multiple services (Carse et al., 2013; Cervero & Radisch, 1996; Jacobs, 1993; Schwanen & Mokhtarian, 2005a). Accordingly, Melia (2014) observed that within car-free residential areas the quality and accessibility of offered services such as public transport or education-, sports- and shopping facilities are more enhanced. Next to the quality of offered facilities and services, the quality of the built environment and urban planning in these areas appear to be high and contributing to the overall quality of life of its residents (El Din et al., 2013).

Borges and Goldner (2015) note that people younger than 65 years old and households with children are more likely to live in a car restricted residential area. The last is supported by the observation of Scheurer (2001), noting that on average occupants of residential areas are part of larger household sizes.

Another important finding is that people living in a car restricted residential area employ a different travel behaviour compared to people living in a conventional residential areas, as multiple studies determined that car restrictions resulted in lower car use and car ownership of residents (Melia, 2014; Nobis, 2003; Scheurer, 2001). This is supported by the opposite observation by Guo (2013a), concluding that the supply of parking facilities does influence the car ownership of households. The study found that residents that are offered car parking close to their homes possess more cars, employ more car trips and drive longer distances. Likewise, Nobis (2003) observed that 81 per cent of households living in the car restricted residential area of Vauban (Freiburg, Germany) previously possessed a car, from which two-third sold their car after moving there. Scheurer (2001) noticed a comparable car ownership reduction in the car-free residential areas of GWL (Amsterdam) and Florisdorf

(Vienna) from respectively 10 and 62 per cent. Ornetzeder et al. (2008) discovered that 41 per cent of the people living in Florisdorf used the bicycle more often than before. Nonetheless, concluded that the decrease in car use was not the effect of moving to a car-free residential area since many residents stated to already have decided to sell the car before moving to the car-free settlement.

Scheurer (2001) found that the car-free character of the neighbourhood was just in some cases a decisive factor. Likewise, Ornetzeder et al. (2008) found that only 23 per cent of residents living in Florisdorf moved there because of the car-free character of the settlement. Yet 73 per cent of the respondents stated that the green and healthy environment was the rationale for moving there, as due to car restrictions, these areas are less eposed to greenhouse gas emissions, air pollution, noise nuisance and 'urban heat islands' (Loo, 2018; Melia, 2014; Minh, 2016; Nieuwenhuijsen & Khreis, 2016). Nevertheless, it is argued that this rationale may in both studies be correlated with the overall pro-environmental behaviour of the respondents. This is supported by the study of Loo (2018) that concludes that people's social and environmental values were underlying the motivation to move to a car restricted area. Ortnetzeder et al. (2008) have found that households that live in a car restricted residential area are more concerned about the environment and had a lower carbon footprint compared to households living in a conventional residential area. However, Loo (2018) observed that not all people with these social and environmental values prefer to live in a car restricted residential area, as they hold different business, educational, daily or social needs (see subsection 2.1.6). Subsequently, Nieuwenhuijsen and Khreis (2016) noted people living in car-free residential areas engage in a more active lifestyle, since their lives are less engaged with car use. Moreover, restricting (private) vehicles directly results in less traffic, which has been indicated by Loo (2018) and Minh (2016) to reduce the risk and accordingly the number of road accidents, resulting in, in terms of traffic, a more safe living environment.

On the social aspect, introducing car restricted areas were found by Ornetzeder et al. (2008) to consequent in more social cohesion and social contacts, as residents were observed to be more willing to help each other. Ornetzeder et al. (2008) examined that residents living in the car restricted residential area of Florisdorf in Vienna were found to have made more friends within the settlement in comparison to conventional residences, and additionally stated that they knew more people by sight. However, Melia (2009) argued that social cohesion among residents could be the consequence of the stakeholder conclusion during the development of the car restricted residential area. Furthermore, Scheurer (2001) concluded from the household sizes living in a car restricted residential area, that these offer a good environment for children. Which is supported by the observation of Nuetzel (1993) and Clayden et al. (2006) that contrarily to conventional streets, children living in home zones (woonerf) could play outside without direct parental supervision at a younger age. In a later study, Melia (2014) supported these conclusions by stating car restricted residential areas to enhance social interaction among residents, reduces the risk and fear of road accidents and provides more independence for children.

Previous studies show that the incentive to relocate in a certain settlement is driven by property-specific, location and personal preferences. For car restricted residential areas only the location and personal preferences are essential in determining the preference for moving to a car restricted residential area. Accordingly, the physical design of the residential area, people's socio-demographic characteristics, travel behaviour and attitudes towards travel modes, residential environment and environment are found to be essential aspects of determining the preferences for living in a car restricted residential area.

Additionally, three studies observed the willingness to live in a car restricted residential area. Borges & Goldner (2015) determined the influence of socio-demographic characteristics on the willingness of people to move to a car restricted residential area. Through logistic regression analysis, they have found that residents of Floriapolis (Brazil) using sustainable modes of transportation, people younger than 65 years old and households with children are more likely to live in a car restricted residential area. Gundlach et al. (2018) studied the trade-off between the design of alternative transport modes and living in a car restricted residential area. Their study found that given the current infrastructure in Berlin (Germany) 60% of their respondents, of which 80% were students, were willing to move to a car restricted residential area. Moreover, they found that improvements to bicycle infrastructure and the network of bus stops and train stations, next to assigning public space to recreational uses would enhance the likelihood of people moving to a car restricted residential area. Nonetheless, only 20% of their sample did own a car, and people owning a car seemed not likely to move to a car restricted residential area. Lastly, Borgers et al. (2008) researched the trade-off between parking at distance and the design of infrastructure in the car restricted residential area. Their study concluded that most people do not prefer to live in a car restricted residential area, however remote car parking in these residential areas can be partly compensated by providing secured parking facilities, good non-motorised transport facilities and access to public transport at a short distance from residences.

Considering the attractiveness of the design of a car restricted residential area, literature indicates that the design of the neighbourhood should consider three aspects. First, it is noted that as cars are restricted from the residential area, the accessibility of the settlement should be maintained, preferably by enhancing public transport, walking and cycling infrastructure. Secondly, the design of parking facilities should be considered, as the vehicular restrictions involve car owners to park their cars in designated places. Lastly, the physical design of the residential environment should be enhanced to compensate for remote parking.

Although these studies provide valuable insights, there is limited research concerning the preference for living in a car restricted residential area resulting from the design of car parking and the design of the physical environment of the settlement. It is unknown how people trade-off the design of car parking to the design of the physical environment of a car restricted residential area. This information is relevant for policymakers, urban developers, and project developers, as currently there is no knowledge of the preference of Dutch car owners for a car restricted residential area in relation to these variables. Establishing neighbourhoods with low parking levels and expensive parking facilities is perceived as a risk, as uncertainty exists about the willingness of car owners to move to these areas and the risk of these costly parking facilities being left unused. Therefore, understanding of the extent to which design variables of car restricted residential areas affect the willingness to move to these areas would be relevant for considering different designs of car restricted residential areas.

3. Research methodology

In transportation and marketing research stated choice modelling has become a commonly used approach to measure individual preferences. However, this method is also used to assess people's preferences for housing types and location choice (Koppelman & Bhat, 2006). This method allows to analyse and predict an individual's choices from a set of alternatives. By this way, the influence of different aspects of the residential area on the willingness to move to a car restricted residential area can be determined. Stated choice data, therefore, provide information on the effects of design changes on the attractiveness of residential areas from the residents' perspective. Knowledge of these effects will support optimising the designs for car restricted residential areas. One main advantage of stated preference (SP) experiments is that they allow studying hypothetic situations, and therefore are ideal to test future situations (Train, 2009). Furthermore, SP experiments, in general, are easier to control, allow more flexibility and are less expensive (Molin, 2018). The hypothetical alternatives in the stated choice experiment are defined by variables that indicate residential area characteristics. Each variable can take on different values or levels that are systematically variated over alternatives. By systematically generating different combinations of these levels, multiple designs for car restricted neighbourhoods are created that are forming the alternatives. The alternatives are combined in sets and form a choice set.

Respondents are asked multiple times to choose one residential from a set of two residential areas, such that it enables modelling the trade-offs people make. This way of collecting data is straightforward and at the same time, multiple observation can be gathered from one individual resulting in larger sample sizes. Under the assumption that people are rational and will choose the alternative that maximises their utility (random utility maximisation), the choices of respondents will be input for statistically deriving the utilities corresponding with the variable levels. The sum of the utilities corresponding to the variable levels of an alternative is called the systematic utility. For an individual, the total utility (U) of an alternative (i) consists of two elements: the systematic utility (V_i) and the error term (ε_i). The summation of the systematic utility and error term provides the total utility that people derive from an alternative. The total utility of a set of alternatives is used to determine the probability that an individual will choose a certain alternative over other alternatives of this set (Walker & Ben-Akiva, 2002). The calculation of this choice probability is dependent on the model that is used, as different models make different assumptions about the probability distributions of the error term (ε).

First, a multinomial logit model is estimated. The model, introduced by McFadden (1974), is nowadays most commonly applied and is mainly favoured due to its simplicity. The formula of the choice probabilities is closed form, which makes de model simple to estimate (Train, 2009). The model assumes that the error terms that are related to the alternatives all have the same probability distribution and are independent of each other (i.i.d. assumption). With these assumptions, error terms are drawn and assigned independently across alternatives. This means that each error term is completely uninformative of all other error terms. This assumption, therefore, ignores the correlation within 'nests of alternatives' and the correlation between choices that are made by the same individual over time (Hensher & Greene, 2003; Louviere, 1988; Train, 2009). This leads to biased estimation of outcomes. To overcome this drawback, a mixed logit (ML) model estimated. The advantage of an ML model over a multinomial logit (MNL) model is that it captures nesting effects, meaning that it seizes the correlations between similar alternatives. Secondly, the ML model assumes that tastes differ across people and within segments (e.g. people may have different preferences regarding parking costs). The correlation between alternatives and choices and heterogeneity across individuals will be captured in unobserved utility (υ). Lastly, an ML model captures the correlation between choices made by the same individual, as a person choosing the alternative with the least walking time to the car parking facilities in the first choice set will presumably choose for the alternative with the least walking time in the second to the last choice as well. Thus, in case alternatives have similarities in one or more factors, and if there are heterogeneous tastes/preferences concerning these dimensions, an ML model will outperform MNL, as it allows to randomly vary utility in terms of these dimensions (Hess et al., 2005). For this reason, this research will estimate an ML model after the MNL model to assess if it is able to fit the data better. Nevertheless, an MNL model will be estimated first, as it a straightforward model and quicker to estimate. The model that fits the data best will be interpreted.

The model performs well in case the predicted probabilities correspond well with the choices of the respondents. Generally, the McFaddens's Rho-square is used to measure the goodness-of-fit of a model (McFadden, 1974). The value of this measure ranges from zero, indicating a bad performance, to 1, indicating that the model performs excellently.

4. Experimental setup

In the stated choice experiment, respondents are presented with two residential area alternatives. These alternatives will consist of several characteristics (attributes) that will be varied over multiple levels (attribute levels). The consolidation of these levels comprises a choice profile and the combination of two alternatives a choice set which is accompanied by a choice task.

4.1 Design variables and choice sets

A literature study was conducted to determine the level of vehicular restrictions that are applied in this study. A car restricted area in this study is distinguished as a visually car-free area, in which access to vehicles is restricted and car parking is either provided in-building, underground or at the edge of the neighbourhood, yet, there is no attempt to limit car use or ownership (Morris, et al., 2009). A selection of design variables included in the model should be made. However, a disadvantage of applying stated preference surveys is that designing these experiments may involve bias from the researcher, as the researcher determines the important attributes (variables) that are incorporated in the design and controls which alternatives are provided (Molin & Timmermans, 2010). Therefore, it is important to include the attributes that respondents find important in the selection of attributes, next to the attributes that are relevant for designing car restricted residential areas (variables that can be influenced by policymakers or the project developers). To overcome this researcher's bias in designing the experiment, this selection will be based on the literature review. This information allows making a substantiated selection of variables that are included in the choice model. The following attributes are selected for this study: (1) walking time to the car, (2) type of car parking facility, (3) monthly car parking costs, (4) type of building in the residential area, (5) the liveliness level in the residential area, (6) facilities the residential area and (7) green facility level in the residential area.

The first three attributes regard car parking because in general car restricted residential areas are accompanied by restricted vehicular access and therefore car parking should be well designed. In most cases, it is not possible to park a car near home, therefore the first attribute covers the walking distance to the car. However, since distances, in general, are difficult to perceive, the distance is adjusted to walking time to the car. On the matter of remote car parking, the type of car parking facility is found to be especially important to residents (Balcome & York, 1993; Borgers et al., 2008). Lastly, parking prices relate to the willingness to park remotely (de Groote et al., 2015). Furthermore, including a cost aspect will allow determining the willingness to pay for the design attributes of the car restricted residential area. Moreover, four physical design aspects are selected, as these influence the incentive to move to a certain residential area (Jarass & Scheiner, 2018; McCormack et al., 2019; Tu & Eppli, 1999). With regard to a car restricted residential area, the building environment and liveliness level have been found as important determinants of their attractiveness (Carse et al., 2013; Cervero & Radisch, 1996; Jacobs, 1993; Schwanen & Mokhtarian, 2005a). Furthermore, as the neighbourhood allows less vehicular traffic, most trips to facilities should be carried out by foot. For this reason, a car restricted residential area should consist of all the facilities that reflect its residents' needs (Loo, 2018). Lastly, it is argued that space normally used for vehicle infrastructure should be assigned to green areas, in fact, people generally prefer the green aspect of car restricted residential areas (Gundlach et al., 2018; Loo & Chow, 2006; Nieuwenhuijsen & Khreis, 2016).

Each neighbourhood aspect will be varied in multiple levels. All attributes will have three levels, which are indicated in Table 1. The levels for walking time to the car parking facility is based on the walking distances of 50m, resembling parking near your house, 400m for parking in a car parking in the street and 750m for car parking at the periphery of the residential area. The walking time is computed with an average walking speed of 5 kilometres per hour. The type of car parking is varied between the combinations of having a private parking space or making use of public parking and an indoor versus outdoor parking. The monthly parking costs are deduced from the subscription costs of parking in a public parking garage in Dutch cities (Gemeente Amsterdam, n.d.; Gemeente Den Haag, n.d.; Gemeente Rotterdam, n.d.; Gemeente Utrecht, n.d.; Planbureau voor de Leefomgeving, 2008; Waard, 2020). The type of building in the residential area is composed of mainly high-rise building, low-rise building, or a mixture of both. Furthermore, the liveliness levels that are selected are derived from the liveliness levels in several types of neighbourhoods. A residential area in or near the centre of a city is characterised by having a lively street scene with not only residents but also trespassers. Other residential areas are portrayed with children playing on the streets or people sitting in the front of their house, and in (as the name indicates) sleeping neighbourhoods hardly anyone can be found on the streets. The levels of facilities that can be found in the residential area are characterised in the same way, as in city centres a broad range of facilities can be found, some neighbourhoods have a neighbourhood centre in which a bakery, flower shop or butcher can be found and suburbs often only have supermarkets. Lastly, the green facilities come in three levels as well, one in which small parks are spread through the neighbourhood, one consisting of one big central park, such as in most cities and one in which the streets are portrayed with wide grass strips and threes throughout the neighbourhood, as sometimes can be found in fringe areas.

Table 1 - Attribute levels of the choice experiment

Attribute	Attribute level 1	Attribute level 2	Attribute level 3
Walking time to the car parking facility	0,5 minutes	5 minutes	9 minutes
Type of car parking facility	Private parking space in a parking garage	Public parking garage	Public parking lot
Monthly parking costs	€ 0,-	€ 150,-	€ 300,-
Type of building in the residential area	Mainly high-rise building	Mainly low-rise building	Mixed high- and low-rise
The liveliness in the residential area	Hardly people on the street	Liveliness street scene with residents	Liveliness street scene with residents and trespassers
Facilities in the residential area	Only a supermarket	A simple range of facilities	A broad range of facilities
Green facilities in the residential area	Small parks spread through the neighbourhood	One big central park	Streets with wide grass strips and threes throughout the neighbourhood

An efficient design is used for drafting the stated choice experiment. As this design requires priors, a prior survey is dispersed. The prior study is drafted based on an orthogonal design. The parameter estimates resulting from this survey are used as priors for determining the efficient design of the final choice experiment. The efficient design is determined resulted in 18 choice sets, that were distributed over three versions of the survey, so each respondent is presented with six choice tasks.

To reduce the choice effort for respondents, respondents are asked to choose between two residential area alternatives that both consist of the same attributes and attribute levels (i.e. unlabelled alternatives). In order to determine the willingness of car owners to move to a car restricted residential area, a base alternative is included in the choice sets. First respondents are presented with the choice between two car restricted residential areas. Thereafter in a second question, the respondent is presented with the choice between the selected residential area and a conventional residential area. The advantage of this manner is that in case a large part of the sample chooses the conventional residential area, the choice data of the two car restricted residential areas can still be used to gain insight into the trade-off between design variables.

By means of an online questionnaire, car owners were asked to imagine that they have to move within six months and accordingly were requested to indicate their preference for designs of car restricted residential areas. In a second question, respondents were asked if they would consider moving to the residential area of their choice over a conventional residential area. Furthermore, the survey contained questions to measure the influence of socio-demographic variables, car use, current residential environment, and attitudes towards car use, living environment and a car restricted living environment. The survey is distributed in diverse residential areas in the Netherlands. An example of a choice task is provided in Table 2.

Table 2 - Example of a choice task

		Residential area 1	Residential area 2
Car parking	*Number of minutes from your residence to the car*	9	0,5
	Type of parking facility	Private parking space in a parking garage	Public parking lot
	Monthly parking costs	€150	€0
Residential area	*Type of building in the residential area*	Mainly low-rise building	Mixed high- and low-rise
	Liveliness level in the residential area	Lively street scene with residents and trespassers	Hardly people on the streets
	Facilities in the residential area	Only a supermarket	A broad range of facilities
	Green areas in the residential area	Small parks spread through the neighbourhood	Streets with wide grass strips and trees throughout the neighbourhood

4.2 Data collection

The population of this research is distinguished by car owners living in the Netherlands. The survey was distributed on social media and through pamphlets that were dispersed in mailboxes. This method of approaching respondents was due to the restrictions on physical contact between people. Accordingly, 5000 pamphlets were spread in multiple neighbourhoods in three cities and two towns: Hilversum, Rotterdam, The Hague, Kortenhoef and Pijnacker. This selection was made to obtain a mix of residential areas and residential environments and to make sure to include respondents of different segments and with different views on car restricted residential areas. In total, the survey reached 6347 people from which 501 opened the survey and 330 finished the survey. The drop out the range, therefore, was equal to 34,2%. Furthermore, people took on average 24 minutes and 10 seconds to finish the questionnaire. 73 respondents were excluded from the data for not taking sufficient time to reliably filling in the survey or not possessing a car. In total the analysed data set contained 257 completely filled in questionnaires.

Of the respondents, 49,8% was male, 35,4% of the respondents were under 35 years of age, 30,4% between 35 and 49 years old and 6,2% were 65 years or older. 44,7% of the respondents finished a middle-level education and 42,0% higher-level education. Likewise, 39,9% of the household incomes of the sample were average and 36,6% of the sample's household income levels were above average. These distributions are compared to the distributions in the population. However, as recent data of this target group is missing, the data of the total Dutch population is used as a proxy of the population numbers. The sample seems somewhat younger than compared to the population and the educational and household income level of the sample is higher than in the population. Moreover, the percentage of more person households in the sample (84,4%) is higher than in the population (61,7%). Lastly, the sample consists, compared to the sample, of a large number of people living in Amsterdam, Rotterdam, The Hague or Utrecht (respectively 14,0% to 53,7%). The sample does not fully represent the Dutch car owners, which may have implications for the interpretation of the results, as this can affect respondents'responses to certain questions and choice situations.

4.3 Model estimation

In order to estimate the choice model, the non-linear variables were transformed into linear variables through effect coding. The residential design variables, the socio-demographic, car use, current residential environment variables were coded. Moreover, the attitudinal variables were constructed through factor analysis and summated scales of these latent attitudes are included in the model.

Initially, an MNL model is estimated consisting of three alternatives; two car restricted residential areas and one opt-out alternative (moving to a conventional residential area). The ultimate MNL model is established by repeatedly extending the utility functions of the alternatives. The model that consists of only the variables that are altered in the choice experiment is considered the base model. As they represent the attributes of the alternatives, the model will always contain these variables, even if these variables turn out to be insignificant. Subsequently, it is scrutinized if the goodness-of-fit can be enhanced by including the variables that were also assessed in the survey in the model specification. These variables are the socio-demographic characteristics, car use, current housing and attitudes concerning car restricted residential areas and car use. The corresponding variables were stepwise added to the model in these specific clusters. The variables that are not significant are excluded from the model. The Rho-square value of the basic model was 0,187, after adding the socio-demographic, car use, current living environment and attitudinal variables and subsequently removing the insignificant variables was 0,235.

Next to the MNL model, a Mixed Logit (ML) model was estimated. The estimation process was performed with the same stepwise approach as the estimation of the MNL model. For the estimation of the model, Monte-Carlo simulation was applied, which uses draws taken from a normal distribution. In the estimation process of the ML model, the number of draws was repeatedly increased until the results became stable. Again, it was tested whether adjusting the model would lead to an increased model fit, if this was not the case then the adjustments should be considered not to improve the model and therefore should be removed from the model. First, nesting effects were captured in the model, meaning that the model takes into account the similarities between alternatives. Secondly, panel effects were included, which implies that the model considers that individuals made multiple decisions and that correlation between these decisions may exist. Subsequently, the possibility of people having different preferences regarding design variables were included, thereby allowing random taste heterogeneity among respondents. This last model was supplemented with the significant socio-demographic, car use, current residential environment, and attitudinal variables of the MNL model. The Rho-square value after removing the insignificant variables was 0,265.

The results indicated that multiple variables that seemed to significantly influence the willingness to move to a car restricted residential area, as indicated by the results of the MNL model, do not significantly affect the car owners' willingness to move as expressed by the results of the ML model. This difference originates in the assumptions of the MNL model, that may lead to incorrect estimation outcomes. Moreover, the Rho-square values of both models indicated that the ML model fits the data better than the MNL model. Which is also indicated by the Ben-Akiva and Swait test, assessing if the model fit of the ML model significantly increased to the MNL model. For this reason, the results of the ML model will be presented, interpreted, and discussed. The estimation results of the ML model are presented in Table 3.

The Rho-square value of the ML model equals 0,265. This indicates that the model is able to explain 26,5% of the initial uncertainty. Thus, compared to having no understanding of car owners' choice behaviour considering the willingness to move to a car restricted residential area, the model is able to clarify 26,5% of the choice behaviour. Yet, at the same time, this indicates that the choice behaviour of respondents is dependent on more than the observed variables only.

5. Results

The results presented in Table 3 suggest that only a few car owners prefer to live in a car restricted residential area over a conventional residential area, especially if they use their car daily or primarily for private purposes. Furthermore, on average car owners do not prefer to walk several minutes to their car except households with children younger than 6 years old that may perceive longer walking times with a higher traffic safety grade. Likewise, most car owners do not like paying for parking their car, except people that are currently used to pay for residential car parking or currently have their car parked at 1 minute of walking or less from their homes. Furthermore, people dislike a neighbourhood in which there is hardly any activity of people on the streets or a neighbourhood in which the green area only comprises one big central park. Supporters of car restricted residential areas like a neighbourhood containing only a supermarket, while there is an aversion to the offer of a small range of facilities such as a bakery, flower shop and cafés additional to a supermarket. Overall, the walking time to and monthly price for parking significantly decrease to the willingness to move to a car restricted residential area, while the physical environment of a car restricted residential seems to be of less importance. This implies that improvements to the physical environment should be traded off carefully to the location and price of parking facilities. Lastly, the results indicate that residence owners are, opposite to residence renters, more willing to move to a car restricted residential area.

In terms of traffic safety, traffic nuisance, presence of footpaths, bicycle infrastructure and presence of green areas the expectations of car restricted residential areas are very high. Nevertheless, these expectations, just as attitudes towards car use and quality of the living environment, did not seem to influence the willingness to move to a car restricted residential area.

Furthermore, the estimation results were used to indicate the importance of the variables. The importance of each variable can be quantified by calculating the variables' relative importance based on the coefficients and the value range of every variable. The value range of each attribute is the difference between the highest and the lowest estimated part-worth utility of the corresponding levels. By summing the ranges of all the variables, the percentual contribution of each variable can be determined The resulting relative importance of each variable is presented in Figure 2.

The figure displays that the design variables together make up for around 10% of the relative importance. However, of these attributes, the walking time to the car parking facility and monthly car parking costs seem to have the highest relative importance of respectively 3,3% and 4,2%. And the design variables 'hardly people on the street', 'only a supermarket', 'a simple range of facilities' and 'one big central park' are the least important variables. Moreover, the figure shows that people's current walking time to the car by far is the most important variable, with a relative importance of 31,6%. This is followed by household size and the number of children in the age category 0-5 years, with a relative importance of respectively 17,0% and 12,3%. The other variables representing car use, such as daily usage, primarily private purpose usage and the monthly car parking arrangements all have a relative importance around 5%. Furthermore, current house ownership arrangements (i.e. resident owners and resident renters) has a relative importance of 6,3%.

Table 3 - Utility values per variable

Variable	Variable level	Parth-worth utility
Alternative specific constant car restricted residential area		-2,16
Attributes of the alternatives		
Walking time to the car parking facility	Minute of walking time	0,0787
Type of car parking facility	Private parking space in a parking garage (1)	-0,214*
	Public parking garage (2)	0,191*
Monthly parking costs	Euro of monthly parking costs	0,00285
Type of building in the car restricted residential environment	Mainly high-rise building (1)	-0,0173*
	Mainly low-rise building (2)	-0,223*
Liveliness level in the car restricted residential environment	Hardly people on the street (1)	-0,221
	Lively street scene with residents (2)	0,0298*
Facilities in the car restricted residential environment	Only a supermarket (1)	0,338
	A simple range of facilities (2)	-0,288
Green facility level in the car restricted residential environment	Small parks spread through the neighbourhood (1)	0,154*
	One big central park (2)	-0,199
Socio-demographic variables		
Household composition	*Interaction* between time and household size	-0,0776
	Interaction between time and kids between 0 – 5 years	0,139
Car use		
Frequency of car use	Daily base (1)	-1,28
Purpose of car use	Private (1)	-0,66
Current walking time to the car	*Interaction* between Price and Walking time car	-0,00214
Current parking	*Interaction* between Price and Pays monthly for car parking (1)	-0,0024
	Interaction between Price and Bought a car parking space (2)	0,00477
Current residential environment		
House ownership	House renter	-0,636*
Sigmas	Mainly high-rise building (1)	-0,706
	One big central park (2)	0,345
	Hardly people on the street (1)	0,437
	Walking time to the car parking facility	0,0756
	Alternative specific constant car restricted residential area	4,02

* Not significant at 95% significance level

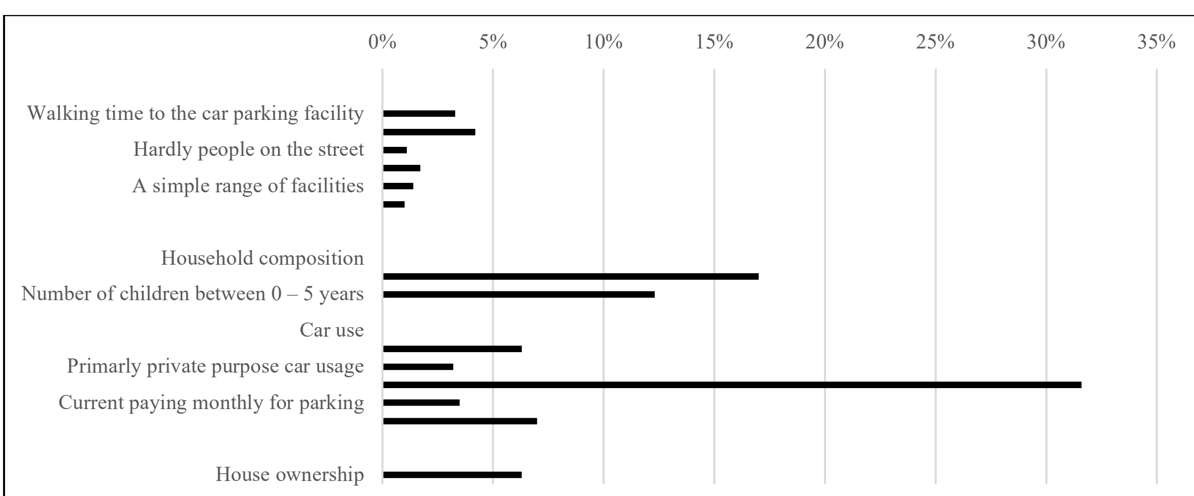

Figure 1: Relative influence of variables on the willingness to move to a car restricted residential area

6. Application

The model results then used to gain an understanding of how each design variable influences the willingness to move to car restricted residential area. It is calculated what the effect of adjustments in the design of car restricted residential area is on the percentage of car owners willing to move to a car restricted residential area. The extent to which the percentage of car owners willing to move changes as a result of adjustments in attribute values is determined through elasticities. For the influence of household size and the number of children between 0-5 years old in the household on how the walking time is perceived, the average population numbers are used. The same applies to the distribution of residence purchasers to residence renters. For the influence of current walking times and current parking arrangements on how the parking costs in a car restricted residential area are perceived, the distributions of the sample are used. This also applies to the distribution of people that use their car daily and use their car primarily for private purposes. Therefore the contribution of these variables represents the average change on the percentage car owners willing to move to a car restricted residential area. Figure 1 indicates per design variable the influence of changing the design considering this design variable on the percentage of car owners willing to move. Furthermore, the effect of the car usage and house ownership arrangements on the percentage of car owners willing to move to a car restricted residential area are included in the figure.
The design variables 'public parking garage', 'mixed high and low-rise buildings', 'lively street scene with residents and trespassers', 'only a supermarket' and 'small parks spread throughout the neighbourhood' do have a significant contribution to the percentage of car owners willings to move to a car restricted residential area. On the other hand, 'walking time to the car parking facility', a 'private parking space in a parking garage', 'mainly low-rise building', 'hardly people on the street', 'a simple range of facilities' and 'one big central park' seem to decrease the percentage of car owners willing to move to a car restricted residential area over moving to a conventional residential area.

Most importantly, each minute of walking time up to 9 minutes decreases the percentage of car owners willing to move to a car restricted settlement over a conventional settlement with on average 13,5%. Likewise, every increase of €25,- to the monthly parking costs up to €300,- will decrease the willingness with on average -1,1%.

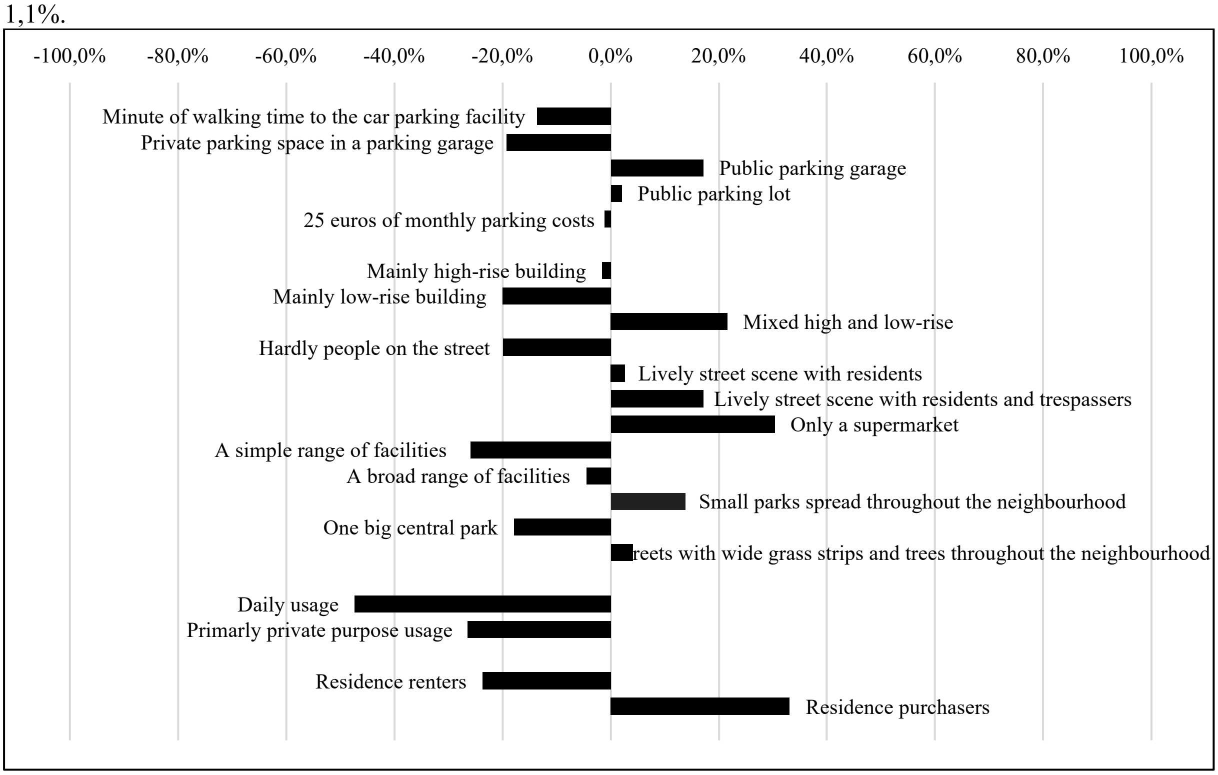

Figure 2: Extent to which the willingness to move to car restricted residential areas changes due to design variable level moderations

Furthermore, a car restricted residential area will on average be 47,3% less appealing to car owners using their car on a daily base. The same applies to people that use their car primarily for private purposes, a car restricted residential area will on average be 26,5% less appealing to them. A car restricted residential area will furthermore be on average 23,7% less appealing to people that currently rent a residence, on the other hand, on average people that currently own a house are 33,1% more likely to move to a car restricted residential area.

The model results are used to draft several designs of car restricted residential areas. The designs are used to gain an understanding of how each design variable influences the willingness to move to a car restricted residential area. Furthermore, multiple versions of Dutch new development projects of a car restricted residential areas are used as examples to establish four designs of potential applications of car restricted residential areas; (1) a spacious urban district design, (2) a spacious suburban design, (3) a compact urban district design, and (4) a compact suburban design.

Overall, the willingness of car owners to move to a car restricted residential area is low and most people seem to prefer to live in a conventional residential area. On average 3% of the car owners preferred to move to a car restricted residential area over moving to a conventional residential area. Spaciously designed car restricted residential areas, characterised by higher levels of green space and lower levels of liveliness, are less attractive to car owners. Compact car restricted residential areas, however, seem to be slightly preferred amongst car owners, which may be due to their higher levels of liveliness, higher contributions of high-buildings, and lower levels of green areas.

7. Discussion

The results suggest that people negative value the walking time to the car parking facility. This implies that people are not in favour of walking several minutes to their car. This is in line to the results of the study of Borgers et al. (2008) that found when considering living in a car restricted residential area, people have a negative association with having to park from the residence. Even though Christiansen et al. (2017) observed that on average people are willing to walk 100 metres (approximately one minute) from their residence to their car. Their study found that walking time to the car has a negative effect on car ownership and car use and thus walking time is perceived negatively as well. Furthermore, the results indicate that more person households have a negative association with walking time to car parking facilities and that, on the other hand, households with children younger than 6 years old are willing to accept longer walking times to the car parking facility. This is in contrast to the findings of Christiansen et al. (2017) that have found that people with young children are less willing to accept longer distances to residential car parking facilities. They have found that younger people and people that live in apartment buildings are willing to walk further to residential car parking facilities, whereas, people with young children and people who already have good access to car parking are less keen on walking to their parked car. Yet, the positive association of walking time to the car parking of households with younger children found in this study may be related to the range in which their children can play safely outside. Which has been found to be an important advantage of living in a car restricted residential area by its residents (Scheurer, 2001; Nuetzel, 1993; Clayden et al., 2006; Melia, 2009).

Equal to the negative associations with walking times to the car parking, monthly car parking costs are not preferred by car owners. This is supported by the fact that in general people try to minimise their costs. Likewise, van der Waerden et al. (n.d.) have found that people only are willing to pay for parking in their residential area when a secured car parking is offered or this will increase the probability of a free space close to their residence. Antolín et al. (2018) have found that especially residents perceive parking costs and walking times to car parking facilities worse that non-residents, implying that on average residents do not favour walking to or paying for car parking facilities. Furthermore, a literature review performed by Parmar et al. (2020) shows that for residents out-vehicle costs such as parking costs and walking time to the car parking are more important than in-vehicle costs, such as the fuel costs and travel time. Additionally the results indicate that car owners currently parking their car at a walking distance of 1 minute or less, currently pay periodically for parking their car in their neighbourhood or lastly bought a car parking spot are willing to pay monthly for car parking in a car restricted residential area. Guo and McDonnell (2016) support these findings and have found that people that currently pay for car parking are willing to pay more for residential car parking for car parking in hypothetic residential areas.

Furthermore, the favour for a public garage and the disfavour for a private parking space in a parking garage, on the other hand, was not anticipated. As it was expected that people would prefer a private parking space in a parking garage over a public parking garage. However, this may be the result of psychological factors, since the study of Parmar et al. (2020) indicated that the difference between public and private parking space is not important to people, as long as they are convenient and safe. Furthermore, Guo (Guo, 2013b) has found that while households own a private garage, they still often prefer parking on-street. This provides clarification for people's evaluation of private car parking facilities.

Only having a supermarket in the neighbourhood was not expected to be favoured, as it was assumed that having more facilities in the neighbourhood would enhance residents' daily life in a car restricted neighbourhood. This expectation was in line with the findings of McCormack et al. (2019) and Brookfield (2016) that observed local facilities to be an important factor in people's residential choice. Especially in car restricted residential areas, the presence of various facilities offering multiple services was found to be important in fulfilling it's residents' preferences and needs (Carse et al., 2013; Cervero & Radisch, 1996; Jacobs, 1993; Loo, 2018;

Schwanen & Mokhtarian, 2005b). This preference may be related to the expectation of respondents of the presence of facilities such as supermarket, shops, and catering to be lower in a car restricted residential area compared to their current residential area. Yet, several studies state that having supermarkets on walkable distances from residences is found to be a most important aspect for residents in walkable cities such as car restricted residential areas (Sinniah et al., 2016; Perrotta et al., 2012).

Considering green areas, a car restricted residential area consisting of only a central park is valued negatively. Zhang et al. (2017) studied the influence of quality and quantity of green areas in neighbourhoods on neighbourhood satisfaction. They have found that the accessibility and usability of green spaces are more important than the dimension of green areas. This may indicate that people's association with one big central park in the neighbourhood is negative as the degree of accessibility of the green area in the neighbourhood is lower compared to multiple green parks throughout the neighbourhood or grass strips and trees in every street.

The results of this research additionally indicate that for different designs of car restricted residential areas on average 3,0% of the car owners would choose to move to a car restricted residential area over a conventional residential area. This differs from the results of Gundlach et al. (2018) finding that 60% of their respondents would choose to live in a car restricted residential area and improvements to bicycle infrastructure could even increase this percentage to 90%. In this research, the car restricted neighbourhood design with the highest willingness to move would only result in 13,7% of car owners preferring a car restricted residential area over a conventional residential area. Therefore, the willingness to move levels found in this study may seem fairly low. However, it should be stated that only 20% of the respondents in the research of Gundlach et al. (2018) owned a car, and therefore may be more appealed to living in a car restricted residential environment. Moreover, their research also observed that car owners were less likely to move to a car restricted residential area.

Considering the finding that the willingness to move to a car restricted residential area is slightly higher than a conventional residential area in compactly designed neighbourhoods, Mouratidis (2018) found that residents of compact-cities derive more value to the physical environment of their neighbourhoods in terms of safety, the existence of parks and squares, limited noise, traffic and litter. They found that especially in compact cities enhancements to the physical environment contribute to a more liveable environment. This may explain the slight increase to the willingness of car owners to move to a car restricted residential area compared to conventional residential areas in compact urban districts and compact suburbs. Furthermore, more than half of the sample indicated to live in Amsterdam, Rotterdam, The Hague or Utrecht, and a high percentage of the sample stated to live in the city centre or off-city centre. This implies that most residents currently live in a compact residential area, which may have resulted in a high willingness to move to car restricted residential area with a compact design.

Moreover, it should be stated that the willingness to move to a car restricted residential area is furthermore interrelated to the supply of residences in non-car-restricted residential areas. This is also supported by various researches that state that the available number of alternatives indicate the freedom people have in the selection process. Thereby, the supply of residences in conventional residential areas may influence the willingness to move to a car restricted residential area (Borgers et al., 2008; De Vos et al., 2012; Lin et al., 2017; Molin & Timmermans, 2010). Even though there currently is a housing shortage, the residences offered still are located in conventional residential areas, which may influence the choice behaviour of car owners.

Furthermore, this research was not able to assess whether the observations by this research are generalisable outside the Netherlands. This is uncertain because it is unknown to what extent the willingness to move to car restricted residential areas among Dutch car owners differ from foreigners. For example, the findings of Gundlach et al. (2018), stating that if bicycle infrastructure is enhanced, the preference for a car restricted residential area in Berlin would increase with 30%. However, as in the Netherlands, the quality of bicycle infrastructure in most newly developed residential areas is already fairly high, therefore this influence on the willingness to move to a car restricted residential area may be less in the Netherlands. So in case, the urban design standards are different between countries, the preference for the car parking arrangements and physical design variables, as the willingness to move to a car restricted residential area may differ as well.

Considering the effect of car use on the willingness to move to a car restricted residential area, it seems that car owners daily using their car and/or using their car for primarily private purposes are less keen on moving to a car restricted residential area. This may be supported by the conclusion of Guo (2013a), noting that the supply of parking facilities does influence the car use and car ownership of households. The study found that residents that are offered car parking close to their homes possess more cars, employ more car trips and drive longer distances. Therefore the car parking arrangements and car restrictions in car restricted residential areas may be less appealing to people using their car frequently.

Even though Stubbs (2002) concluded that the proximity of car parking to occupants' residences is one of the most important aspects of designing car parking facilities in residential areas and residence occupiers appear to be less likely to purchase a house if the car parking arrangements are not fulfilling, still this study indicates that residence owners are, opposite to residence renters, more willing to live in a car restricted residential area. Which may imply that people investing in a residence are more concerned about their residential environment than residence renters. This is supported by the study of Groote, et al. (2017) that note that the residential environment reflects the investment potential of the residence

Furthermore, it was expected that ideologies and habits would strongly influence the preference for living in a car restricted residential area. Especially as there is high heterogeneity in the average willingness to move to a car restricted residential area, meaning that people have different associations with living in a car restricted residential area. However, attitudes regarding car use and quality of the living environment and expectations of car restricted residential areas did not seem to influence the preference to move to a car restricted residential area. Likewise, Ettema and Nieuwenhuis (2017) found that attitudes towards travel modes and residential location choice are to a limited extend related. It is assumed that people have unobserved associations with the concept of a car restricted neighbourhood, which may be resulting from the emotional preferences people may associate with living in a car restricted residential area. These preferences may be resulting from rational preferences based on objective criteria. Besides, many researchers studied the interrelations between residential choice behaviour, travel behaviour, built environment and travel mode attitudes and suggest that not only attitudes influence people's behaviour, but this effect may also work the other way around as well. Nevertheless, only a few studies provide strong empirical evidence on this discussion. Among which a study of Bothe (2010) which concludes that travel behaviour and built environment characteristics have a stronger effect on travel-related attitudes than the other way around. This is supported by a study of Kroesen et al. (2017) indicating that travel behaviour affects travel mode attitudes to a greater extent than vice versa. These findings may clarify the non-significant effect of attitudes on residential choice behaviour found in this study.

8. Conclusion

This researched aimed to increase the insight into the willingness of car owners to move to a car restricted residential area. A car restricted area in this study is distinguished as a visually car-free area, in which access to vehicles is restricted and car parking is either provided in-building, underground or at the edge of the neighbourhood, but there is no attempt to limit car use or ownership. The preferences regarding seven variables affecting car restricted residential choice were studied: (1) walking time to the car, (2) type of car parking facility, (3) monthly parking costs, (4) type of building, (5) liveliness level, (6) amount of facilities, and (7) the degree of green areas. A stated preference (SP) survey was used to determine which characteristics affect this preference, and to what extent. Car owners were asked to indicate their preference for designs of car restricted residential areas and accordingly if they would consider moving to the residential area of their choice over a conventional residential area. Furthermore, the survey contained questions to measure the influence of socio-demographic variables, car use, current residential environment, and attitudes towards car use, living environment and a car restricted living environment. The data of 257 respondents was used to estimate and interpreted a mixed logit (ML) model.

It has been found that only a few car owners prefer to live in a car restricted residential area over a conventional residential area, especially if they use their car daily or primarily for private purposes. Furthermore, on average car owners do not prefer to walk several minutes to their car except households with children younger than 6 years old that may perceive longer walking times with a higher traffic safety grade. Likewise, most car owners do not like paying for parking their car, except people that are currently used to pay for residential car parking or currently have their car parked at 1 minute of walking or less from their homes.

For municipalities considering developing a car restricted residential area, the main recommendations are the following: (1) Do not assign to much value to a car restricted residential area, at least not in terms of the physical environment since only a few car owners would prefer to move here over a conventional residential area. (2) Consider the locations of the car parking facilities carefully as longer walking times exponentially decrease the willingness to move to a car restricted residential area. (3) Only introduce car parking costs if necessary, as only a few will be willing and able to pay for car parking. (4) It is not essential to facilitate private parking spaces, a public parking garage will suffice. An additional benefit of a public arrangement is the opportunity for shared usage to enable an increased overall occupancy rate per parking space, which may be essential in case public space is scarce. Shared usage may not only optimise parking but may also increase the parking's revenue and thus may reduce the car parking costs for residents. (5) Apply a car restricted residential area in case, due to limited space, a compact design is required. (6) Establish an adaptive design of car parking facilities that allows adapting to a possible shift from car ownership to car sharing. The design of car parking facilities should, therefore, incorporate the flexibility to transform into a mobility hub or to be assigned to different functions, e.g. retail facilities.

The main recommendations for future research are the following: (1) Perform additional qualitative research to increase the understanding of people's association towards car restricted residential areas. (2) Develop a hybrid choice model to research the influence of attitudes on the preference for the design variables and moving to a car restricted residential area. (3) Develop an integrated conjoint choice model to include more aspects of the neighbourhood and thereby resemble the residential location choice behaviour of people better. (4) Perform the same stated choice experiment with another sample to see whether the degree of willingness to move to a car restricted residential area is comparable to what has been found in this research.

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B

Appendix: Theory of methodologies

B.1 Stated preference versus revealed preference data collection

Within the discrete choice analysis, the distinction can be made between collecting data of revealed preference (RP) and stated preference (SP). The substantial advantage of the first data collecting method is that it generates information about the actual choice behaviour of persons in real-world situations (Train, 2009). The latter requires persons to make choices within predefined choice sets, which may include inexistent alternatives and choice specific characteristic values that are outside the current value range (Brown, 2003). The difference between RP and SP is therefore that SP can be used to test hypothetical situations (Train, 2009). For this reason, this specific method is ideal to test future situations. Furthermore, SP experiments, in general, are easier to control, allow more flexibility and are less expensive (Molin, 2018a). In this research SP data is used, for the reason, that car restricted residential areas are not widely applied in the Netherlands and this research it is preferred to observe the influence of several design variables on the choice for these residential areas.

The SP data will be used for estimating preferences among different alternatives. The values of characteristics are variated over alternatives, such that it enables modelling the trade-off between an attractive living environment and the walking distance to the car parking facilities. This way of collecting data is more straightforward and multiple observations can be gathered from an individual, resulting in larger sample sizes. Nevertheless, a drawback of stated preference is that this hypothetical choice behaviour of persons may not correspond with the actual choice made in reality, indicated as hypothetical bias (Wardmann, 1998). This originates in the hesitation people have to convey their true choices, or people may even choose tactically due to the expectation that their choices influence the actual interventions that will take place as a result of the research outcome (Kroes & Sheldon, 1998.; Randall, 1994).

Another advantage of stated preference surveys is that people, either aware or unaware, make choices throughout the day. Brown (2003) therefore states that it is less difficult for respondents to rank, rate or select alternatives, rather than determining directly how much time one is willing to travel to the car in return for enhancements of the physical living environment (which is done in direct surveys).

One disadvantage of applying SP is that designing SP experiments may involve bias from the researcher, as the researcher determines the important attributes (variables) that are incorporated in the design and controls which alternatives are provided (Molin & Timmermans, 2010). Therefore, it is important to include the attributes that respondents find important in the selection criteria, next to the attributes that are relevant for designing car restricted residential areas, implying variables that can be influenced by the project developers. To overcome this researcher's bias in designing the experiment, a theoretical framework will be used as input for creating the survey. The theoretical framework will be established through a literature review. The overview of variables that results of this review will facilitate making a selection of variables that will be included in the choice experiment. This information allows making a selection of variables that are included in the choice model. Thus the selection of variables must be made with care as this is likely to reduce the researchers' bias and thereby increases the likelihood of obtaining reliable and validate outcomes.

B.2 Theory on discrete choice modelling

B.2.1 Random utility maximisation

Discrete choice models allow analysing the choice behaviour of persons. These models are able to reveal to what degree the design variables affect the decisions of an individual (Koppelman & Bhat, 2006). The models used in this research will estimate the choice behaviour of persons according to the random utility maximisation (RUM) theory. This theory implies that individuals will select the alternative that, according to them, yields the most utility (Walker & Ben-Akiva, 2002). Utility indicates the value a person obtains from the attributes of an alternative (Koppelman & Bhat, 2006, p. 14). The stated choice experiment used in this research will contain three alternatives: residential area (1), residential area (2) and (3) a conventional residential area (base alternative). These alternatives each have different utility functions that determine the utility per alternative.

Total utility

The total utility (U) that an individual derives of an alternative (i) includes two elements: the systematic utility (V_i) and the error term (ε_i). The systematic utility of an alternative is formed by the summation of the utilities corresponding to the attribute levels of that specific alterative. The total utility of alternative i is conveyed in Equation B.1.

$$U_i = V_i + \varepsilon_i \qquad \text{(B.1)}$$

The first part of the utility function, the systematic utility (V_i), corresponds to the variables that are observed (Koppelman & Bath, 2006). The observed variables in this research are the attributes of the residential areas that are forming the alternatives in the choice task (e.g. walking time to the car parking facilities) and the additional variables that are measured in the questionnaire (e.g. household size, age). The second part of the utility function, the error term (ε_i) is shaped by everything else (i.e. unobserved variables, randomness in choices). For every observed factor in the utility function, an additional parameter (β) is determined. This parameter signifies the average value people derive from the corresponding variable (m). The multiplication of this parameter (β_m) and the accompanying value of the attribute (x_{im}) indicates the contribution of that variable to the total utility of that specific alternative (i). By monitoring the observed choices of individuals, the parameters for the attributes can be estimated according to the maximum likelihood principle (Koppelman & Bhat, 2006). This principle determines the set of parameters corresponding to the measured variables that make the observed choice behaviour most likely.

Furthermore, the systematic utility part of the utility function can be supplemented by interaction effects. Interaction effects suggest that the contribution of a variable is contingent on the value of another variable (e.g. the time people are willing to walk to their car is dependent on the number of young aged children a household contains). Interaction effects are factors in the model as well and accordingly, a corresponding parameter will be estimated for these factors. The formula for computing the total utility that is associated with alternative i is displayed Equation B.2.

$$U_i = \sum_m \beta_m \cdot x_{im} + \varepsilon_i \qquad \text{(B.2)}$$

Alternative specific constant

Additionally, the utility function of an alternative can be enhanced with an alternative specific constant (ASC). The total (average) utility people associate to an alternative other than the observed attributes is captured by the ASC (Koppelman & Bhat, 2006). In other words, this constant can be used to capture the preference for a specific alternative that cannot be disclosed by the observed variables (e.g. the hassle of parking remotely). The ASC represents the utility of the alternative apart from the contribution of the alternatives (i.e. their values are fixed to zero). This, therefore, allows determining the (average) preference for an alternative that cannot be explained by the observed variables (Koppelman & Bath, 2006). Hence, it can be stated that an ASC represents the utility that individuals derive from the associations they possess of an alternative (e.g. car restricted residential area or conventional residential area). The utility functions of the two car restricted residential area alternatives that used in this study contain an ASC that signifies the average utility that is associated with moving to a car restricted residential area related to moving to a conventional area.

B.2.2 Choice probabilities

The total utility (U) of alternatives (i) is used to determine the choice probabilities of a set of alternatives j (i.e. the chance that an individual prefers a certain alternative over other alternatives in a set of alternatives j). The main interest of this research is the probability of an individual preferring to move to a car restricted residential area over moving to a conventional residential area. The calculation of this choice probability is dependent on the choice model that is used, as different models make different assumptions on the probability distributions of the error term (ε). These differences will be elaborated in the next section.

B.2.3 Discrete choice models

Multinomial Logit model

In this research, a multinomial logit (MNL) model is drafted first, as this model is more straightforward to estimate. This model, promoted by McFadden (1974), is the most commonly applied discrete choice model and is mainly favoured due to its simplicity (Train, 2009). The formula which is used to calculate the choice probabilities is closed form, which makes the model simple to estimate (Train, 2009). The chance of an individual selecting alternative i from a set of alternatives j can be calculated with Equation B.3 (McFadden, 1974, Train, 2003):

$$P\ (i) = \frac{\exp\ (V_i)}{\sum_{j=1 \dots J} exp(V_j)} \qquad \text{(B.3)}$$

The model, however, makes the presumption that the error terms corresponding to the alternatives are all distributed equally and are independent of each other (i.i.d. assumption). With these assumptions, error terms are drawn and assigned independently across alternatives. This means that each error term is completely uninformative of all other error terms. This assumption, therefore, ignores the correlation within 'nests of alternatives' and the correlation between multiple choices conducted by the same person over time (Hensher & Greene, 2003; Louviere, 1988; Train, 2009). This leads to biased estimation of outcomes.

Mixed logit model

To subdue the risk of biased estimated parameter results, secondly, a mixed logit (ML) model is estimated. An ML model consists of three main aspects that counterbalance the prior described drawbacks of the MNL model.

<u>Nesting effects</u>

The first advantage of the ML model its ability to seize nesting effects, meaning that it captures correlations between similar alternatives and choices. Conversely, the MNL model makes the assumption that random errors are i.i.d. distributed, thereby this model neglects the presence of nests of alternatives that have similarities in observed and unobserved variables. In case these alternatives show resemblance, this may result in the error terms being correlated. In this case, assuming that the errors are i.i.d distributed is not valid. Preserving this assumption of the MNL model may lead to biased parameter estimates and by that flawed choice probability forecasts. An MNL model, in general, overestimates the probabilities of alternatives that are correlated. Yet, these nesting effects will be seized in the ML model by supplementing the utility function with an additional error component (υ) (Hensher & Greene, 2003). The total utility of alternative i, therefore, can be computed with Equation B.4.

$$U_i = \sum_m \beta_m \cdot x_{im} + \upsilon_n + \varepsilon_i \tag{B.4}$$

The additional error component υ captures the utility people derive of the unobserved variables in the nest. Thus, when two or more alternatives have something in common this induces variation in utility across individuals who are not seized in the systematic part of utility. Therefore, in the ML model the error terms are assumed to be correlated and the i.i.d. the assumption for determining the error term does not apply. As the two cars restricted residential areas in this research contain the same attributes, the ML model presumes the error terms of the car restricted residential area alternatives to be correlated. For this reason, an additional error component (υ) will be included in the utility functions of the car restricted residential area alternatives. This supplementary component indicates the utility of their similar unobserved variables. Equation B.5 denotes how the probability that an individual (n) chooses alternative (i) can be computed (Train, 2009).

$$P_i = \int_{\upsilon_n} [(P_{ni}|\upsilon_n) \cdot f(\upsilon_n)] \cdot d\upsilon_n \tag{B.5}$$

<u>Taste heterogeneity</u>

Secondly, as the parameters of factors (β) are fixed, and MNL model assumes incorrectly that tastes (β) are the same within (segments) of the population. Yet, in reality, these tastes differ across people and within segments (e.g. tastes regarding parking costs are likely to differ within the high-income segment). Since the parameters of the variables are fixed, the MNL model does not capture this unobserved taste heterogeneity. Therefore, the model overlooks the correlations between the utilities people derive from unobserved variables that are associated with the attributes that alternatives have in common. ML models, however, assume that preferences for different attributes vary across people and within segments. Therefore, the model seizes the different preferences by allowing one or more parameters (β) to vary across individuals. The different unobserved preferences of individuals are distinguished as unobserved taste heterogeneity. The variation across individuals is following density function f(β) and the parameters are estimated by making repeated draws from a joint density. With the parameter estimate results, the choice probabilities per alternative are determined through simulation. In other words, the estimated parameters are improved in an iterative way, which encloses first making draws from a probability density function and secondly evaluating the conditional choice probabilities for the alternatives. Through simulation, these steps are repeated various times to calculate the choice probabilities in such a way that they are an average for the sample. The formula for estimating the choice probabilities is expressed in Equation B.6 (Train, 2009).

$$P_i = \int_{\upsilon_n} \int_{\beta_{n,m}} \left[(P_{ni}\middle|\upsilon_n, \beta_{n,m}) \cdot f(\upsilon_n, \beta_{n,m})\right] \cdot d\upsilon_n d\beta_{n,m} \tag{B.6}$$

<u>Panel effects</u>

Lastly, the MNL model incorrectly makes the assumption that an individual's choices over time are uncorrelated. Yet, in reality, individuals have unobserved tastes and preferences that influence their choices. Intuitively this means that these unobserved utilities, that are captured in the error term, are in fact correlated (e.g. a person choosing the alternative with the least walking time to the car parking facilities in the first choice set will presumably choose for the alternative with the least walking time the second choice as well). Nevertheless, an MNL model assumes that errors are white noise across alternatives and observations. Thus, the assumption is made that unobserved utilities of alternatives that are evaluated by the same individual are uncorrelated, which means that the decisions made by the same individual are assumed to be uncorrelated. By preserving this assumption, the model underestimates the standard errors of the parameters. Thereby, parameters seem significant considering the outcome of the MNL model, while they are not. Yet, ML models capture the correlation between an individual's choices over. By seizing these panel effects the model presumes that multiple decision of the same individual are correlated. This results from the variation in preferences and tastes across individuals and stability in preferences and tastes within the individual. The ML model allows for unobserved heterogeneity in preferences (e.g. hassle of parking remote) and tastes (e.g. walking time to the car) and makes these preferences and tastes constant in time (i.e. individual-specific). The unit of observation thereby becomes the series of choices made by one individual (i.e. panel data). In that way, it is possible to capture the correlation between choices that are made over time (t) by the same individual (n). Again, simulation is used to compute the choice probabilities, however, in this case, each draw is used to calculate the choice probability for an individual's sequence of choices. In this way, the ML acknowledges that an individual's preference for the base alternative (moving to a conventional residential area) will influence all the following choices as well. As a result, the model fit generally increases significantly when comparing an MNL to an ML model based on panel data (i.e. Panel Mixed Logit). The choice probabilities are calculated with Equation B.7 (Train, 2009).

$$P_i = \int_{\upsilon_n,\beta_n} \prod_{t=1}^{T} [(P_{ni}^t | \upsilon_n, \beta_n) \cdot f(\upsilon_n, \beta_n)] \cdot d\upsilon_n d\beta_n \tag{B.7}$$

Concludingly, an ML model can overcome several drawbacks of the MNL model. In case alternatives have similarities in one or more factors, there is a correlation between the choices one individual makes, or if there are heterogeneous preferences concerning attributes, an ML model will outperform MNL, as it allows to randomly vary utility in terms of these dimensions (Hess et al., 2005). For this reason, this research will estimate an ML model after the MNL model to assess whether it is able to fit the data better. Nevertheless, an MNL model will be estimated first, as it a straightforward model and quicker to estimate. The model that fits the data best will be interpreted and used to answer the research questions.

B.2.4 Goodness-of-fit

Thus, this research will estimate two models (1) an MNL and (2) an ML model. However, solely the model that is able to fit the data best will be interpreted and used to provide answers for the research questions. For determining the degree to which a model fits the data properly, different methods can be used. One of these methods is through observing the log-likelihood. Since the MNL and ML model applies the Maximum Likelihood-principle to compute the parameters estimates that make the data most likely, the model with the highest log-likelihood value will by definition be able to explain the choice data better. The log-likelihoods of both models can be compared to assess which model performs best in explaining the data accurately. The log-likelihood can be computed by multiplying the loglikelihood overall chosen alternatives (i), as $y_n(i)$ equals zero when the alternative is not chosen and one of the alternatives is chosen, and all observations (n) (see Equation B.8).

$$LL(\beta) = \sum_n \sum_i P_n(i|\beta)^{y_n(i)} \tag{B.8}$$

The McFaddens' Rho-squared (ρ^2) value is a popular method to describe the goodness of fit of a model. This method allows to compare the model's estimation performance (LL_β) with the performance of the null model (LL_0).

The rho-squared value can be calculated by Equation B.9 (McFadden, 1974).

$$\rho^2 = 1 - \frac{LL_\beta}{LL_0} \tag{B.9}$$

The rho-squared value lies by definition between 0 and 1. A rho-squared value that equals 0 signifies a model that performs equal to throwing a dice (i.e. does not know anything). Whereas a rho-squared value of 1 implies that the model perfectly fits the data, which means that every choice is predicted correctly (Koppelman & Bhat, 2006). Thus a higher log-likelihood value of the final model implies that the final model performs better in explaining the data. Nevertheless, a model cannot predict every choice made by people correctly. A drawback of determining the model fit through the rho-squared value is that there is no ground rule of what a 'good' rho-squared value (i.e. a 'good' fit) is (Koppelman & Bhat, 2006). The value can, therefore, be explained as being the percentage of the initial uncertainty that is rationalised by the model. Furthermore, an issue of interpreting the rho-squared value is that including variables to the model, increases the degrees of freedom. Therefore, adding more parameters will always increase the rho-squared value, independent of the significance of these variables. For this reason, the rho-squared value will be used to identify how much of the original uncertainty can be explained by the information provided by the model. Whereas the assessment of the performance of the two models will be carried out by the likelihood ratio test.

Assessing whether the increase in model fit is significant

Since both the MNL and the ML model are based on the same data it may be a coincidence that the second model reports a higher log-likelihood value than the first estimated model. To test can be applied to determine if the change in log-likelihood values is significant: (1) the Ben-Akiva & Swait test and (2) the likelihood ratio statistic (LRS) test (Koppelman & Bhat, 2006). The second test is used in case a model $\propto$ is a nested model from model β, meaning that one can obtain model $\propto$ (null-model) from the set of parameters of model β (i.e. by constraining parameters). If this is not the case (non-nested models), for example when comparing different decision rules, the Ben-Akiva & Swait test is used. In this research first, an MNL model will be estimated. Subsequently, this model will be supplemented by the additional error terms that the former described ML models apply. The MNL model, therefore, can be seen as a restricted model of the ML model and thus a is a nested model of the ML model. For this reason, the likelihood ratio test will be carried out to test if the ML model outperforms the MNL model. The nested model can be rejected when the LRS value is higher than the threshold value of the corresponding significance level. The LRS value can be calculated by Equation B.10.

$$LRS = -2 * (LL_\propto - LL_\beta) \tag{B.10}$$

Furthermore, it can be stated that if the additional error terms of the ML model are not significant the ML model is perceived to be an improvement of the MNL model, as the additional parameters are not able to explain the data better.

B.3 Theory on factor analysis

Additional to the discrete choice analysis, a factor analysis will be carried out. Because it is likely that in addition to observed variables that will be measured in the survey (such as walking time to car parking facilities, people's current car travel behaviour, current residential environment and socio-demographic characteristics), unobserved factors such as attitudes towards living in a car restricted residential area could influence people's choices as well. As attitudes are, in general, often implicit and not easily measured directly, an exploratory factor analysis will be performed. This analysis allows exploring the underlying factors influencing peoples' choice behaviour.

B.3.1 Reducing dimensions

A factor analysis aims to decrease the number of dimensions that define an original space. It does so by identifying a smaller number of new dimensions that capture the dimensions that defined the original space. These newly identified dimensions will then span the new space (Rietveld & van Hout, 1993) The original space is commonly composed of measured variables and the new space of the variables underlying the measured variables. The variance between the variables that are observed are expressed in underlying (i.e.latent) factors (Habing, 2003). The simplified factor structure facilitates obtaining a coherent overview of the measured data. Besides, the output of the factor analysis provides the advantage of employing in subsequent analysis (Field, 2000; Rietveld & van Hout, 1993) Thus, without imposing any preconceived structure of the result, a factor analysis allows identifying the underlying structure of a set of associated variables.

The factor analysis is performed based on the correlation matrix that represents the correlations between the studied variables. New dimensions can be extracted by identifying which variables correlate highly with a set of variables, while at the same time correlating low with variables outside that group. In this way, new dimensions can be extracted whereby the original number of dimensions of the correlation matrix can be scaled down (Field, 2000). The group of variables that have high intercorrelations together distinguish one underlying variable, which in the case of a factor analysis is identified as a factor. This factor expresses a new dimension of the new (latent) space, which can be projected on an axis (Field, 2000). The first identified factor is composed of the set of variables that cover the maximum amount of common variance. Subsequently, the remaining common variance of sets of variables is captured in the second till last factors until (almost) no common variances can be identified.

B.3.2 Eigenvalue

The strength of the variance of the observed variables is represented by the eigenvalue of the factor. The eigenvalue is a measure to what extent the factor explains the variance of the observed variables. The Eigenvalue (Kaiser) criterion is used to determine the number of factors that are identified in the analysis (Kaiser, 1960). An eigenvalue equal to or higher than one means that the factor can explain more variance than a single observed variable and therefore taken into account in the analysis (Nunnally, 1978). The resulting factor structure of this process represents the latent constructs. Every original variable that is part of an identified factor possesses a factor loading and a factor score. The value of the factor loading signifies the degree of the correlation of the original variable (statement) with the factor. The factor score, on the other hand, can be used for computing new scores that can be applied in subsequent analysis (Field, 2000).

B.3.3 Criteria for an exploratory factor analysis

However, before starting this process some important criteria should be considered. The first criterion states that it is essential that the initial variables are measured at an interval level. This is because the performance of the factor analysis is funded on the correlation matrix of the original variables.

Moreover, the second criterion is that the original variables must be distributed normally. This makes it possible to generalise the results of the analysis (Field, 2000). At last, it should be reviewed whether the size of the sample is sufficient to perform exploratory factor analysis. The higher the sample size, the less the correlations may be affected by outliers, which improves the reliability of the factor analysis (Habing, 2003). To test whether the sample size is big enough the Kaiser-Meyer-Olkin (KMO) measure is applied. A KMO value that is higher than 0,5 indicates if the sample size is sufficient to perform a factor analysis (Field, 2000).

B.3.4 Factor rotation

There is a chance that it is too hard to interpret and label the factors that are extracted. To facilitate the interpretation of the factors factor rotation techniques are applied. Factor rotation transforms the pattern of the factor loadings which can facilitate the interpretation. The rotation of factors can be clarified by visualising the identified factors as axes in a graph on which the initially measured variables load. These axes are can be rotated, which makes clusters of variables load more optimally. Two rotation techniques can be distinguished: (1) orthogonal rotation and (2) oblique rotation. The first technique rotates axes at a 90-degree angle. This rotation technique assures that there is no correlation between the factors, whereas in second rotation technique the factors are correlated (Field, 2000). The selection of which rotation technique to apply depends on whether there is a theoretical foundation to assume that the factors are interrelated or independent. A simple solution in deciding which rotation technique to employ is to perform the factor analysis using both the orthogonal rotation and the oblique rotation. In case that the results of the oblique rotation display that the factors are correlated, the oblique rotation technique is preferred, whereas results showing a negligible correlation between the extracted factors, imply to use the orthogonal rotation. Multiple methods can be applied for factor rotation. SPSS covers three orthogonal rotation techniques, being *varimax*, *quartimax* and *equimax*, and two oblique rotation techniques: the *direct oblimin* and *promax* rotation. The most applied orthogonal rotation technique that is applied is the *varimax* rotation. The objective of this technique is to determine a structure that assures each variable to load highly to only one factor and a structure in which each factor only contains a small number of the initial variables. The second method, *quartimax*, aims to minimise the number of factors. Lastly, *equimax* integrates the aims of the *varimax* and *quartimax* methods.

Direct oblimin is the most applied oblique rotation technique. This method aims to find a rotation of the originally extracted factors that minimise the cross product of the factor loadings. This will generate a simple-structured solution because the cross product is small when many of the factor loadings are close to zero (Field, 2009). The promax method takes a varimax factor-loading matrix and creates a new matrix by raising the factor loadings to some exponent (kappa, typically assigned value 4). Rotating factors in this way will reduce the factor loading, which simplifies the structure (Field, 2009).

The orthogonal rotation technique derives a rotated component matrix which displays the factor loadings of the initial variables corresponding to the determining factors after the rotation. Additionally, the results contain a transformation matrix that displays the angle of the factor rotation. The products of an oblique rotation are (1) a pattern matrix, (2) a structure matrix and (3) a component correlation matrix. The first matrix displays the regression coefficients of the variables on each of the factors, which are identified as pattern loadings. The second outcome presents the structure loadings, meaning the correlations between the variables and the factors. This structure matrix facilitates interpreting the factors. The last matrix displays the correlation between the extracted factors. This component correlation matrix supports selecting which rotation technique to apply (Rietveld & van Hout, 1993).

C

Appendix: Examples of restricted residential areas

C.1 Past and current cases

With all challenges coming with car dense cities, it may be hard to perceive that up to the start of the twentieth century, almost all cities were car-free. However, even earlier, when horse-drawn carriages were used, cities were overcrowded and noisy. During ancient times, the Roman Empire even put restrictions on carriages in Rome to reduce congestion. Hence vehicles with wheels were not allowed to move through the streets of the city during the day (Spielvogel, 2014, p. 159). Still, car-free settlements can be observed such as the by Crawford (2000) mentioned the largest car-free area of the canal city of Venice with a population of 70.000 people. Current car-free settlements that were examined and characterised by Melia (2009) as historic areas whose physical structure does not allow access to cars, settlements not served by roads such as islands, alpine regions or holiday resorts, university campuses, pedestrianised city centres and lastly newly built car-free residential areas.

Newman and Kenworthy (2015) examined the city planning development through history and identified three main city types: walking-cities, public transport or transit-cities and car-cities. These three types were formed, according to Jones (2014), in the time frames; medieval city, pre-war and post-war. Regarding Ortego-Sanchez et al. (2016) transport policies that were drafted after the war, were at first car movement focused. Thereafter the focus shifted back to the transit- and walking-city structure, introducing policies emphasising the facilitation of people's mobility, ensuring people's accessibility and improving the quality of life.

With the in section 2.1.2. mentioned motives in mind more car-free residential areas were developed. The residential areas of Hammarby Sjöstad (Stockholm, Sweden), GWL (Amsterdam, the Netherlands), Bo01 Västra Hammnen (Malmö, Sweden) Vauban (Freiburg, Germany) and Florisdorf (Vienna, Austria) were designed following a sustainable rationale (Chorherr, GWL terrein Amsterdam, Ortego-Sanchez et al., 2016, Peters, 2019, Rosenthal, 2009). Other initiatives were developed with the purpose of serving a nice and quiet neighbourhood, such as Discovery Bay in Hong Kong, which eventually turned in to eco-friendly area as well (Loo, 2018). Furthermore, the design of the superblock Poblenou in Barcelona showed how car-free developments can be realised within a city's current physical structure. The superblock structure, i.e. a combination of 3 x 3 blocks, facilitates introducing green and leisure space in the enclosed streets while maintaining the city's functionality at the streets that form the outline of the superblock (Nieuwenhuijsen and Khreis, 2016). Ortego-Sanchez et al. (2016) found that some car-free developments, such as Vauban and Florisdorf, realise the car-free characteristics by setting parking or ownership restrictions. Other initiatives such as in the cities of Lausanne, La Rochelle and Helsinki try to accommodate car use by implementing car-sharing systems. Concerning the neighbourhood of Slateford Green in Edinburgh, the housing association noticed during the development of the settlement that 83 per cent of the people on the waiting list did not own a car and accordingly decided to make the neighbourhood car-free.

C.1.1 Visualisation of facilities in several car restricted residential areas

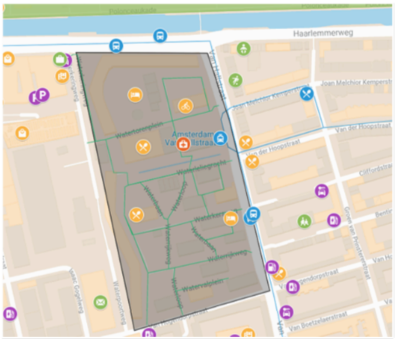
In Figures C.1 to C.7 multiple car restricted residential areas are visualised using data from Google Maps (2020). Each visualisation is included with a map visualising the facilities in the car restricted residential areas. In which differently coloured marks represent different facilities:

- Blue: public transportation facilities
- Purple: car parking facilities
- Red: health facilities
- Light green: daily facilities: educational facilities and supermarkets
- Orange: non-daily facilities: retail and food facilities
- Dark green: green areas

From the figures, it can be concluded that each car restricted residential area that is visualised located car parking facilities at the periphery of the residential area and that most residential areas are included with public transport stops. Furthermore, all residential areas have daily facilities such as supermarkets and educational facilities within the neighbourhood and even non-daily facilities such as retail and food facilities are present in all the residential areas. The car restricted residential area Discovery Bay is the oldest settlement, whereas Superilla del Poblenou is the most recently built settlement. Most are newly developed residential areas, such as Discovery Bay, Vauban, GWL-terrein, Hammarby Sjöstad, Musterleidlung Florisdorf and BO01 Västra Hamnen, others are developed within existing areas, such as the Superilla del Poblenou. Their occupants vary between 1800 and 33500 people. Accordingly, their surface varies between 0,06 to 7,02 square kilometres. Even though the distance to the city centre seems to be an important factor in the attractiveness of a car restricted residential areas, not all residential areas seem to be located near the city centre, Discovery Bay and Musterleidlung Florisdorf have even a distance of more than 10 kilometres from the city centre.

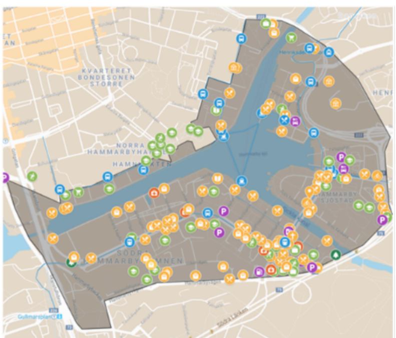
Figure C.1: Discovery Bay, Hong Kong, China

Figure C.2: Vauban, Freiburg, Germany



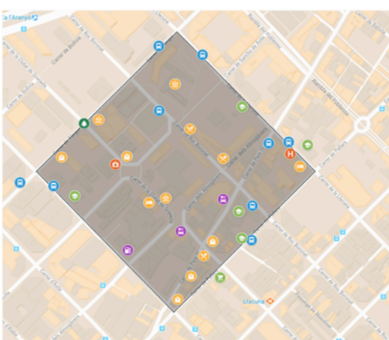
GWL-terrain, Amsterdam, the Netherlands	
Year of construction	1997
Population	1800
Surface	0.06 km^2
Distance central station	2.70 km

Figure C.3: GWL-terrein, Amsterdam, the Netherlands



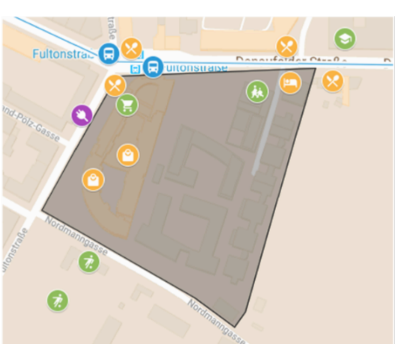
Hammarby Sjöstad, Stockholm, Sweden	
Year of construction	2001
Population	6250
Surface	1,87 km^2
Distance central station	1,60 km

Figure C.4: Hammarby Sjöstad, Stockholm, Sweden



Superilla del Poblenou, Barcelona, Spain	
Year of construction	2006
Population	33500
Surface	0,16 km^2
Distance central station	6.50 km

Figure C.5: Superilla del Poblenou, Barcelona, Spain



Musterseidlung Florisdorf, Vienna, Austria	
Year of construction	1999
Population	16000
Surface	0.36 km^2
Distance central station	11.80 km

Figure C.6: Musterseidlung Florisdorf, Vienna, Austria

Figure C.7: BO01 Västra Hamnen, Malmö, Sweden

C.2 Planned car-free initiatives

Just as the current car-free initiatives, several city councils are emphasising on the city enhancements at the human level. However, opposite to the current initiatives, are planning to completely push out cars from their city centres. Oslo did try to ban cars from its city centre, as the majority of the residents were observed not to drive cars. However, these plans faced resistance from business owners, worried that it would establish difficulties with deliveries and would lead to a customer decrease (Peters, 2015). Hence the local government took a more gradual approach by first removing parking spots within the city's centre. This approach does not only prohibit vehicles to park, at the same time the measure creates space for active ways of transport. Similarly, Hamburg prefers to implement a green network that prohibits cars and enhances routes for pedestrians and bicycles, creating a more human-friendly environment. The planned 'green network' should cover 40 per cent of the city's area, providing safe, car-free travel routes for its residents and visitors.

Moreover, outside Europe initiatives are planned such as in Chengdu, China, where plans for the Great City are drafted. The city is designed following a satellite structure, which enables that any location is reachable within a 15-minute walking range. Hence, cars would not become essential, and as a result, integrating cars will not be necessary. The 1.3 square kilometre surface of the city should accommodate 80.000 people, that all will have the opportunity to work within the settlement (Adrian Smith + Gordon Gill Architecture, 2012). Consequently, this will enhance the inhabitants' car independence.

In the United States, the first car-free neighbourhood will be introduced. Culdesac Tempe will house 1000 people and no private cars. The car-free settlement will be characterised by public courtyards, greenery and grocery and shopping within walking distance. Car ownership and on-site car parking will be restricted. Nevertheless, shared bicycle, scooter and car services will supply longer distance trips. Furthermore, the light rail will connect the settlement with Tempe's city centre, the airport and Arizona State University (Toussiant, 2019).

Within the Netherlands, multiple cities are overthinking or even already developing plans for car-free neighbourhoods. These initiatives vary in scale and are planned from Groningen to the Zaanstreek and cities within the Randstad. The Merwedekanaazone in Utrecht will be the first new developed car-free settlement in the Netherlands that will be designed with 1 parking space per 3 houses. This is unique for an area located within the city centre, yet will be set the new standard for other cities within the Netherlands. Mobility on-demand services will facilitate in the mobility needs of residents that do not own a private car (Gemeente Utrecht, 2020).

Furthermore, municipalities are gradually banning cars from their streets, by transforming car lanes to public transport or bicycle lanes, or by introducing low emission zones (Garfield, 2017).

D

Appendix: Survey design

Ngene output final survey

Choice situation	alt1.time	alt1.type	alt1.price	alt1.buidling	alt1.live	alt1.facilities	alt1.green	alt2.time	alt2.type	alt2.price	alt2.buidling	alt2.live	alt2.facilities	alt2.green	Block
1	5	2	0	2	0	1	2	5	0	300	1	2	0	1	3
2	0.5	2	300	1	0	0	0	5	0	0	2	2	0	2	1
3	0.5	1	150	1	1	0	2	9	2	150	0	0	1	1	3
4	9	0	300	2	0	0	1	0.5	2	0	0	2	1	0	2
5	0.5	2	150	2	2	2	2	9	0	150	0	1	1	1	2
6	0.5	0	0	0	1	2	0	9	1	300	1	0	1	2	1
7	5	0	0	0	2	0	1	9	2	300	1	1	2	0	1
8	9	1	0	0	0	1	0	0.5	2	300	2	1	0	1	3
9	5	0	150	1	2	0	0	5	1	150	2	1	2	2	3
10	0.5	1	300	2	1	1	0	9	2	0	1	2	2	2	2
11	5	0	300	0	0	1	2	0.5	1	0	2	1	2	1	2
12	5	2	150	0	0	2	1	5	1	150	1	2	1	0	2
13	5	2	0	1	1	0	2	5	0	300	2	2	2	0	1
14	0.5	1	300	0	2	1	1	9	0	0	1	0	0	0	3
15	9	0	300	1	1	2	2	5	1	0	2	0	0	1	1
16	9	1	0	2	1	2	1	0.5	2	300	0	0	0	0	2
17	9	2	150	2	2	1	0	0.5	1	150	0	0	2	2	1
18	9	1	150	1	2	2	1	0.5	0	150	0	1	1	2	3

E
Appendix: Final survey

Welkom

Beste deelnemer,

Deze enquête is onderdeel van mijn afstudeeronderzoek aan de Technische Universiteit Delft, in samenwerking met Goudappel Coffeng.
Dit onderzoek gaat over parkeren in de woonomgeving.

Door deel te nemen aan de enquête stemt u ermee in dat uw antwoorden opgeslagen worden en gebruikt voor statistische analyse. Uw antwoorden blijven echter vertrouwelijk en worden geanonimiseerd opgeslagen en verwerkt. De resultaten van deze vragenlijst dragen bij aan mijn masterscriptie, welke online gepubliceerd zal worden.

Ik stel het zeer op prijs dat u een bijdrage wil leveren aan dit onderzoek door deze enquête in te vullen.
Het invullen van de vragenlijst zal ongeveer 15 minuten in beslag nemen.
Alvast hartelijk bedankt voor uw medewerking.

Mocht u vragen of opmerkingen hebben over deze enquête, dan kunt u contact opnemen met

Carmel de Nies
c.a.denies@student.tudelft.nl

Bent u in het bezit van een auto?

- Ja, ik beschik over mijn eigen auto (1)
- Ja, mijn huishouden beschikt over een auto (2)
- Nee (3)

Display This Question:

If Bent u in het bezit van een auto? = Nee

Bent u van plan een auto aan te schaffen binnen nu en vijf jaar?

- Ja, binnen nu en 6 maanden (1)
- Ja, over 7 tot 12 maanden (2)
- Ja, over 13 tot 18 maanden (3)
- Ja, over 19 tot 24 maanden (4)
- Ja, over 25 tot 36 maanden (5)
- Ja, over 37 tot 48 maanden (6)
- Ja, over 49 tot 60 maanden (7)
- Nee, ik verwacht niet binnen nu en vijf jaar een auto aan te schaffen (8)

Skip To: End of Block If Bent u van plan een auto aan te schaffen binnen nu en vijf jaar? = Nee, ik verwacht niet binnen nu en vijf jaar een auto aan te schaffen

Skip To: End of Block If Bent u van plan een auto aan te schaffen binnen nu en vijf jaar? = Nee, ik verwacht niet binnen nu en vijf jaar een auto aan te schaffen

Over hoeveel auto's beschikt uw huishouden?
(u mag ook bedrijfswagens meetellen)

- 1 (1)
- 2 (2)
- 3 of meer (3)

Beantwoord de volgende vragen voor de auto waar u het meest gebruik van maakt.

Hoe vaak maakt u gebruik van de auto (als bestuurder)?

- ○ (vrijwel) elke dag (1)
- ○ 5-6 dagen per week (2)
- ○ 3-4 dagen per week (3)
- ○ 1-2 dagen per week (4)
- ○ 1-3 dagen per maand (5)
- ○ 6-11 dagen per maand (6)
- ○ 1-5 dagen per jaar (7)
- ○ minder dan 1 dag per jaar (8)

Hoeveel kilometer rijdt u ongeveer per jaar?

- ○ 0 - 2.499 kilometer (1)
- ○ 2.500 - 4.999 kilometer (10)
- ○ 5.000 - 7.499 kilometer (11)
- ○ 7.500 - 9.999 kilometer (12)
- ○ 10.000 - 12.499 kilometer (2)
- ○ 12.500 - 14.999 kilometer (13)
- ○ 15.000 - 19.999 kilometer (14)
- ○ 20.000 - 24.999 kilometer (15)
- ○ 25.000 - 29.999 kilometer (3)
- ○ 30.000 - 39.999 kilometer (4)
- ○ 40.000 - 49.999 kilometer (5)
- ○ 50.000 kilometer of meer (9)

Hoe vaak maakt u gebruik van uw auto tussen 22:00 en 6:00 uur?

- ○ (vrijwel) elke dag (1)
- ○ 5-6 dagen per week (2)
- ○ 3-4 dagen per week (3)
- ○ 1-2 dagen per week (4)
- ○ 1-3 dagen per maand (5)
- ○ 6-11 dagen per maand (6)
- ○ 1-5 dagen per jaar (7)
- ○ minder dan 1 dag per jaar (8)

Wat voor soort auto heeft u of uw huishouden in het bezit?

*In het geval dat u of uw huishouden meerdere auto's bezit, kies dan de optie die van toepassing is op de auto die u het meest gebruikt.**

- ○ Auto in eigen bezit (1)
- ○ Auto van de zaak (2)
- ○ Lease auto zakelijk (4)
- ○ Private lease auto (5)

Voor welk doeleinde gebruikt u uw auto voornamelijk?

- ○ Privé (1)
- ○ Zakelijk (2)
- ○ Zakelijk en privé (3)

Wat is het bouwjaar van uw auto?

____

Display This Question:

If Wat voor soort auto heeft u of uw huishouden in het bezit? In het geval dat u of uw huishouden me... = Auto in eigen bezit

In welk jaar heeft u uw auto aangekocht?

____

Display This Question:

If Wat voor soort auto heeft u of uw huishouden in het bezit? In het geval dat u of uw huishouden me... = Auto in eigen bezit

Hoeveel euro heeft u destijds betaald voor uw auto?

____

Display This Question:

If Wat voor soort auto heeft u of uw huishouden in het bezit? In het geval dat u of uw huishouden me... != Auto in eigen bezit

In welk jaar heeft u uw auto verkregen?

____

Display This Question:

If Wat voor soort auto heeft u of uw huishouden in het bezit? In het geval dat u of uw huishouden me... != Auto in eigen bezit

Wat was de cataloguswaarde van uw auto?
(Indien u het bedrag niet weet is een schatting voldoende)

____

Bent u in het bezit van een privé parkeerplaats? (garage, oprit, privéplek in parkeergarage)

- ○ Nee (2)
- ○ Ja, ik ben in het bezit van een garage (1)
- ○ Ja, ik ben in het bezit van een oprit (3)
- ○ Ja, ik ben in het bezit van een privéplek in een parkeergarage (4)
- ○ Anders: (5) ____

Waar parkeert u gewoonlijk uw auto wanneer u thuis komt?

- ○ Binnen, in mijn eigen garage (1)
- ○ Binnen, in een gedeelde garage (2)
- ○ Binnen, in een buurtgarage (3)
- ○ Buiten, op mijn oprit/onder de carport (4)
- ○ Buiten, in mijn straat, voor mijn huis (5)
- ○ Buiten, in mijn straat, maar vlak voor mijn huis parkeren lukt zelden (6)
- ○ Buiten, in een straat ergens in mijn buurt, want in mijn straat is het verboden te parkeren (7)
- ○ Buiten, in een straat ergens in mijn buurt, want in mijn straat is het meestal volgeparkeerd (8)
- ○ Buiten, op een parkeerterrein (9)
- ○ Anders: (10) ____

Op hoeveel minuten lopen van uw huis parkeert u uw auto gewoonlijk?

____

Woning en woonomgeving

In wat voor soort woning woont u momenteel?

- ○ Huur (1)
- ○ Koop (2)
- ○ Overig: (3) ____

Display This Question:

If In wat voor soort woning woont u momenteel? = Huur

Hoeveel bedraagt uw huur per maand? (afronden op een veelvoud van 50 euro)

____

Display This Question:

If In wat voor soort woning woont u momenteel? = Koop

Wat was de aanschafwaarde van uw woning? (afronden op veelvoud van 25.000)

____

Hoe zou u uw huidige woonomgeving beschrijven?

- ○ Centrum-stedelijk (1)
- ○ Buiten centrum-stedelijk (2)
- ○ Groen-stedelijk (3)
- ○ Centrum-dorps (4)
- ○ Buiten centrum-dorps (6)
- ○ Landelijk (5)

Op hoeveel minuten lopen van uw woning vindt u de volgende voorzieningen? (in minuten lopen)

	Aanliggend aan mijn woning (1)	minder dan 3 min (2)	3 - 5 min (3)	5 - 10 min (4)	10 -15 min (5)	15 - 20 min (6)	20 - 25 min (7)	25 - 30 min (8)	meer dan 30 min (9)
Parkeervoorzieningen (1)	○	○	○	○	○	○	○	○	○
Groenvoorzieningen (park, plantsoen, bos, hei, etc.) (2)	○	○	○	○	○	○	○	○	○
Dagelijkse voorzieningen (supermarkt, basisschool) (3)	○	○	○	○	○	○	○	○	○
Niet-dagelijkse voorzieningen (winkels, gezondheidszorg, fitnesscentra, middelbare school) (4)	○	○	○	○	○	○	○	○	○
Recreatie (bioscoop, museum, theater, zwembad) (5)	○	○	○	○	○	○	○	○	○

Hoe zou u uw woonomgeving omschrijven in de volgende termen?

	Enorm ontevreden (1)	Ontevreden (2)	Niet ontevreden, niet tevreden (3)	Tevreden (4)	Enorm Tevreden (5)
Verkeersveiligheid (1)		○	○	○	○
Geluidsoverlast door verkeer (2)	○	○	○	○	○
Verkeersdrukte (3)	○	○	○	○	○
Beschikbaarheid van parkeerplaatsen (4)	○	○	○	○	○
Bereikbaarheid van parkeerplek vanaf uw woning (5)	○	○	○	○	○
Aanwezigheid van fietspaden en fietsparkeerplaatsen (6)	○	○	○	○	○
Aanwezigheid van voetpaden/trottoirs (7)	○	○	○	○	○
Aanwezigheid van groenvoorzieningen (8)	○	○	○	○	○
Aanwezigheid parken/plantsoenen (9)	○	○	○	○	○

Bent u van plan te verhuizen binnen nu en vijf jaar?

- ○ Ja, binnen nu en 6 maanden (1)
- ○ Ja, over 7 tot 12 maanden (2)
- ○ Ja, over 13 tot 18 maanden (3)
- ○ Ja, over 19 tot 24 maanden (4)
- ○ Ja, over 25 tot 36 maanden (5)
- ○ Ja, over 37 tot 48 maanden (6)
- ○ Ja, over 49 tot 60 maanden (7)
- ○ Nee, ik verwacht niet binnen nu en vijf jaar te verhuizen (8)

Introductie autoluwe woonwijken

Deze vragenlijst richt zich op parkeren in autoluwe nieuwbouw woonwijken. Een autoluwe woonwijk wordt gekenmerkt doordat autoverkeer zoveel mogelijk plaats vindt aan de randen van de wijk. Het parkeren van auto's vindt dan ook grotendeels hier plaats zodat er zo min mogelijk autoverkeer door woonstraten rijdt. De straten worden veelal gebruikt door voetgangers en fietsers, maar zijn toegankelijk voor langzaam autoverkeer waar dit nodig is (denk aan mensen met een beperking, halen en brengen, bevoorrading, nooddiensten etc.). Om veel gebruik van lopen en fietsen mogelijk te maken zullen voet- en fietspaden en fietsparkeerfaciliteiten in de woonomgeving van hoge kwaliteit en in hoge mate aanwezig zijn. Doordat er minder verkeer in de woonstraten is zal er ook *meer ruimte voor groen* zijn en zal de bewoner *minder geluidsoverlast van verkeer* en een *verbeterde verkeersveiligheid* ervaren.

Samenvattend, een autoluwe woonomgeving wordt gekenmerkt door:

- groen
- autoluw
- rustig
- verkeersveilig

Een impressie van autoluwe woonwijken:

Uitleg wijkontwerpen

In het volgende onderdeel dient u zich voor te stellen dat u **over uiterlijk 6 maanden** wil verhuizen en op zoek bent naar een koopwoning. U vindt een aantal mogelijke woningopties. Deze zijn echter gelegen in een woonomgeving welke geen ruimte biedt voor een parkeerplek voor uw deur waardoor u uw auto op afstand van uw woning moet parkeren. U zult zich voor moeten stellen dat u al verschillende woningen heeft gevonden waar u tevreden mee bent, echter de kenmerken van de woonomgeving en woonprijzen van de woningen verschillen. U krijgt 9 ontwerpen van woonomgevingen voorgelegd waarbij de parkeer- en woonomgeving kenmerken samen met de woningprijs worden gevarieerd.

Per ontwerp worden u twee vragen gesteld:

1. **In welke woonomgeving zou u liever willen wonen?**
2. **Als u binnen 6 maanden zou moeten verhuizen, zou u ervoor kiezen om naar de gekozen autoluwe woonomgeving te verhuizen of voor een niet-autoluwe woonomgeving kiezen?**

Voor het beantwoorden van de eerste vraag moet u kiezen tussen te twee voorgelegde autoluwe woonomgeving. In de tweede vraag wordt u gevraagd om een keuze te maken tussen het verhuizen naar een autoluwe woonwijk binnen 6 maanden of naar niet-autoluwe woonomgeving.

Hieronder volgt een voorbeeld (deze hoeft u niet in te vullen):

		Woonomgeving 1	**Woonomgeving 2**
Auto parkeren	**Aantal minuten lopen van uw woning tot uw auto**	9	0,5
	Type parkeerplaats	Privé parkeerplek in een parkeergarage	Openbaar parkeerterrein
	Prijs parkeren	€150	€0
Woonomgeving	**Type bouw in de woonomgeving**	Voornamelijk laagbouw	Mix van hoog- en laagbouw
	Levendigheid van de woonomgeving	Levendig straatbeeld met buurtbewoners en bezoekers	Nauwelijks mensen op straat
	Voorzieningen in de woonomgeving	Alleen een supermarkt	Een groot aanbod voorzieningen
	Groen in de woonomgeving	Kleine plantsoenen verspreid door de wijk	Straten met brede grasstrook en bomen door de hele wijk

In welke woonomgeving zou u liever willen wonen?

- ○ Woonomgeving 1 (1)
- ○ Woonomgeving 2 (2)

Als u binnen 6 maanden zou moeten verhuizen, zou u naar de gekozen woonomgeving verhuizen?

- ○ Ja, ik zou naar deze woonomgeving verhuizen (1)
- ○ Nee, ik verhuis liever naar een niet-autoluwe woonomgeving (2)

De verschillende niveau's waarop de kenmerken worden gevarieerd worden *hieronder toegelicht:*

Toelichting

Aantal minuten lopen van uw woning tot uw auto

Het aantal minuten lopen tussen uw woning en waar u uw auto kunt parkeren.
De volgende looptijd is mogelijk:

- 0,5 minuten
- 5 minuten
- 9 minuten

Type parkeerplaats

Het soort parkeerplaats waar u uw auto zult parkeren als u thuiskomt.
De volgende types zijn mogelijk:

- Privé parkeerplaats in parkeergarage
  overdekte parkeergarage met toegewezen plaats
- Openbare parkeergarage
  overdekte parkeergarage waarin u geen toegewezen plaats heeft.
- Openbaar parkeerterrein
  onoverdekt parkeerterrein zonder toegewezen plaats

Maandelijkse parkeerkosten

De prijs die u per maand voor het parkeren voor uw auto betaald.
U kunt zich voorstellen dat het realiseren van (ondergrondse) parkeerplaatsen kostbaar is. Het parkeren van uw auto in een autoluwe buurt zal om die reden niet altijd gratis zijn. De volgende prijzen zijn mogelijk:

- €0
- €150
- €300

Type bouw in de woonomgeving

Door welk type bouw wordt uw woning voornamelijk omgeven.
De volgende bouwsoorten zijn mogelijk:

- Voornamelijk hoogbouw
  het grootste gedeelte van de woningen waardoor uw woning omgeven wordt is <u>hoger</u> dan 5 verdiepingen
- Voornamelijk laagbouw
  het grootste gedeelte van de woningen waardoor uw woning omgeven wordt is <u>lager</u> dan 5 verdiepingen
- Mix van hoog- en laagbouw
  uw woning wordt omgeven door een mix van hoog- en laagbouw

*hoogbouw = gebouwen van meer dan 5 verdiepingen
*laagbouw = gebouwen van minder dan 5 verdiepingen

Levendigheid van de woonomgeving

Hoe levendig is uw woonomgeving.
De levendigheid van de woonomgeving kan variëren tussen:

- Nauwelijks mensen op straat
  er lopen, fietsen, spelen of staan nauwelijks mensen op straat

- Levendig straatbeeld met buurtbewoners
  in uw woonomgeving fietsen en lopen of spelen er voornamelijk buurtbewoners op straat

- Levendig straatbeeld met buurtbewoners en bezoekers
  er zijn altijd mensen op straat; te vergelijken met een stadscentrum, waar niet alleen buurtbewoners, maar ook bezoekers van de buurt komen

Voorzieningen in de woonomgeving

De voorzieningen die nabij u woning beschikbaar zijn welke zullen variëren tussen:

- Alleen een supermarkt

- Een eenvoudig aanbod voorzieningen
  denk hierbij aan een supermarkt, en kleine ondernemers zoals een bakker, drogist, bloemenwinkel en horeca

- Een groot aanbod voorzieningen
  grotere winkel(ketens) en voorzieningen als horeca en recreatie zoals bioscoop, theater, museum

Groen in de woonomgeving

De hoeveelheid groen waarmee uw woning omgeven wordt.
De volgende opties zijn mogelijk:

- Kleine plantsoentjes in de woonomgeving
  de straten zijn bestraat en kunnen gebruikt worden als voet- en fietspaden en verspreid over de wijk kunt u kleine plantsoentjes vinden

- Eén centraal park
  de straten in uw woonomgeving zijn bestraat en worden gebruikt als fiets- en voetpaden, in uw woonomgeving is er één centraal park

- Straten met brede grasstrook en bomen door de gehele wijk
  de straten in uw woonomgeving zijn voorzien van voet- en fietspaden met een brede grasstrook en bomen

Keuze experiment

Percepties autogebruik en woonomgeving

In hoeverre bent u het eens met de volgende stellingen?

	Helemaal mee eens (1)	Eens (2)	Niet eens, niet oneens (3)	Oneens (4)	Helemaal mee oneens (5)
Een auto geeft mij het gevoel van vrijheid. (1)	○	○	○	○	○
Ik zou mij zonder auto sterk beperkt voelen in wat ik nog kan doen. (2)	○	○	○	○	○
Ik heb mijn auto nodig om al mijn activiteiten goed te kunnen uitvoeren. (3)	○	○	○	○	○
Ik vind dat reizen met de auto flexibel moet zijn. (4)	○	○	○	○	○
Ik denk dat ik met een auto minder of zonder auto zou kunnen te leven. (5)	○	○	○	○	○
Ik vind naar mijn werk gaan zonder auto een gedoe. (6)	○	○	○	○	○
Ik beschouw de dichtstbijzijnde parkeerplek bij mijn huis in principe als mijn eigen parkeerplek. (7)	○	○	○	○	○
Ik parkeer mijn auto het liefst in het zicht van mijn woning (8)	○	○	○	○	○
Ik rijd extra rondjes tot een parkeerplek dichterbij mijn huis vrijkomt. (9)	○	○	○	○	○
Ik geloof dat een parkeerplek dicht bij mijn woning mijn woningwaarde verhoogt. (10)	○	○	○	○	○
Ik parkeer mijn auto het liefst zo dicht mogelijk bij mijn huis als ik boodschappen bij mij heb. (11)	○	○	○	○	○
Ik vind het belangrijk dat winkels en diensten op loopafstand van mijn woning aanwezig zijn. (12)	○	○	○	○	○
Ik vind dat mijn woonomgeving voetganger vriendelijk moet zijn. (13)	○	○	○	○	○
Ik vind het belangrijk dat kinderen een plek te hebben in hun woonomgeving waar ze kunnen spelen. (14)	○	○	○	○	○
Ik woon graag in een groene omgeving. (15)	○	○	○	○	○
Ik woon graag in een rustige omgeving. (16)	○	○	○	○	○
Ik vind het belangrijk dat ik contact heb met mijn buren. (17)	○	○	○	○	○
Ik vind het prettig om te wonen in een omgeving waar er altijd mensen op straat te vinden zijn. (18)	○	○	○	○	○
Ik vind dat het ontwikkelen van woningen op hoge dichtheid moet worden aangemoedigd. (19)	○	○	○	○	○
Ik ben van mening dat een woonomgeving autoluw zou moeten zijn. (20)	○	○	○	○	○
Ik vind dat auto's het straatbeeld vervuilen. (21)	○	○	○	○	○

Wat zijn uw verwachtingen van een autoluwe woonomgeving op de volgende gebieden?

	Erg laag (1)	Laag (2)	Niet laag, niet hoog (3)	Hoog (4)	Niet hoog (5)
Verkeersveiligheid (1)	○	○	○	○	○
Geluidsoverlast door verkeer (2)	○	○	○	○	○
Verkeersdrukte (3)	○	○	○	○	○
Beschikbaarheid van parkeerplaatsen (4)	○	○	○	○	○
Bereikbaarheid van parkeerplek vanaf uw woning (5)	○	○	○	○	○
Aanwezigheid van fietspaden en fietsparkeerplaatsen (6)	○	○	○	○	○
Aanwezigheid van voetpaden/trottoirs (7)	○	○	○	○	○
Aanwezigheid van groenvoorzieningen (8)	○	○	○	○	○
Aanwezigheid parken/plantsoenen (9)	○	○	○	○	○

Wat is uw geslacht?

- ○ Man (1)
- ○ Vrouw (2)

Wat is uw geboortejaar?

____

Wat is uw hoogst genoteerde opleiding? (Dit is uw hoogst afgeronde opleiding waarvan u een diploma in het bezit heeft.)

- ○ Basisonderwijs (1)
- ○ Vmbo-b, vmbo-k, mbo 1 (2)
- ○ Vmbo-g, vmbo-t (mavo), havo, vwo- onderbouw (3)
- ○ Mbo 2, mbo 3 (4)
- ○ Mbo 4 (5)
- ○ Havo, vwo (6)
- ○ Hbo, wo-bachelor (7)
- ○ Wo-master, doctor (8)
- ○ Weet ik niet of onbekend (9)

Wat is uw beroepsstatus?

- ○ Student (1)
- ○ Werkend (2)
- ○ Niet werkend (3)

Display This Question:

If Wat is uw beroepsstatus? = Werkend

In welk dienstverband werkt u?

- ○ Werkend, fulltime (40 uur of meer per week) (1)
- ○ Werkend, parttime (minder dan 40 uur per week) (2)
- ○ Anders (3) ____

Display This Question:

If Wat is uw beroepsstatus? = Niet werkend

Wat is uw voornaamste dagelijkse bezigheid?

- Gepensioneerd (1)
- Werkzoekend, op zoek naar een betaalde baan (2)
- Mantelzorger (3)
- Vrijwilliger (4)
- Anders (5) ____

Tot welke categorie behoort ongeveer uw eigen jaarlijkse bruto besteedbaar inkomen? (Dit is het loon voor de aftrek van belastingen)

- Minder dan €10.000 (1)
- €20.000 - €29.999 (2)
- €30.000 - €39.999 (3)
- €40.000 - €49.999 (4)
- €50.000 - €59.999 (5)
- €60.000 - €69.999 (6)
- €70.000 - €79.999 (7)
- €80.000 - €89.999 (8)
- €90.000 - €99.999 (9)
- €100.000 - €199.999 (10)
- €200.000 of meer (11)
- Weet ik niet (12)

Display This Question:

If Wat is uw beroepsstatus? = Werkend

Welke dagdelen werkt u voornamelijk?

- Uitsluitend overdag (1)
- Uitsluitend 's nachts (2)
- Een mix van overdag en 's nachts (4)
- Anders (5) ____

Uit hoeveel personen bestaat uw huishouden (inclusief uzelf)

- 1 persoon (1)
- 2 personen (2)
- 3 personen (3)
- 4 personen (4)
- 5 personen of meer (5)

Display This Question:

If Uit hoeveel personen bestaat uw huishouden (inclusief uzelf) != 1 persoon

Hoeveel personen uit de vorige vraag vallen in de volgende leeftijdscategorieën? (inclusief uzelf)

Jonger dan 6 jaar (1)	▼ 1 (1) ... 3 of meer (3)
6 tot 11 jaar (2)	▼ 1 (1) ... 3 of meer (3)
12 tot 17 jaar (3)	▼ 1 (1) ... 3 of meer (3)
Ouder dan 18 jaar (4)	▼ 1 (1) ... 3 of meer (3)

Hoeveel personen in uw gezin zijn slecht ter been of hebben een lichamelijke beperking?

- ○ Geen (1)
- ○ 1 persoon (2)
- ○ 2 personen (3)
- ○ 3 of meer personen (4)

F

Appendix: Factor analysis

This appendix describes the execution of the factor analysis. Factor analysis is applied to identify the correlation between measured attitudes and aggregating these in new dimensions. This enables to capture observed attitudes in new factors representing underlying attitudes.

First the orthogonal rotation *varimax* was used. This method does not allow a correlation between factors, providing a clear separation of factors, which makes factors easier to interpret. However, it may be that dimensions underlying the statements are correlated. Hence, as an addition to the orthogonal rotation method, the oblique rotation method *direct oblimin* was applied, which allows factors to correlate. The analysis of the 21 attitudinal indicators is performed with the software package SPSS (IBM, n,d).

Before conducting the factor analysis, the data will be reviewed to test whether it is adequate for performing a factor analysis. Subsequently, a description will be provided with the different steps of the *varimax rotation* and *direct oblimin* rotation methods.

F.1 Setting up the factor analysis

F.1.1 Examination of data

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and the Bartlett's Test of Sphericity are used to evaluate if the data is adequate to perform a factor analysis (Bartlett, 1950, Field, 2000). Specifically, case the ratio of respondents to variables is less than 1 to 5 it is suggested to assess the KMO. Even if this is not the case in this study the KMO measure is still performed. A KMO value higher than 0,5 indicates that the sample size is sufficient to perform factor analysis. The Bartlett's Test of Sphericity examines whether the correlation matrix of the statements is an identity matrix, which indicates that the statements are unrelated and therefore unsuitable for structure detection. In other words, it checks if there is a correlation between the variables that can be summarised and captured in new factors. The Bartlett's test of sphericity, therefore, must be significant.

Table F.1 displays the results of the KMO measure and Bartlett's Test of Sphericity. The KMO value is 0,760, indicating that the sample size is sufficient. Moreover, Bartlett's Test of Sphericity is significant. Thus, both tests imply that the dataset is suitable for performing the factor analyses.

Table F.1: KMO and Batrlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,760
Bartlett's Test of Sphericity	Approx. Chi-Square	1590,263
	df	210
	Sig.	0,000

F.1.2 Determination of factor extraction technique

The second step involves determining the factor extraction technique. Generally, two methods are applied for extracting the factors: (1) Principal Component Analysis (PCA) and (2) Principal Axis

Factoring (PAF). These methods differ in the items that are placed on the correlation matrix's diagonal which being evaluated. The first method reports ones, while PAF reports the reliability estimates on the diagonal (Thomposon & Daniel, 1996). In general, PCA concentrates on encapsulating multiple variables into a selection of components (i.e. the latent structures), whereas PAF focusses on the common variance between the variables (i.e. latent attitudes) (Henson & Roberts, 2006). Since this research achieves to identify the latent attitudes considering car use and car restricted residential areas PAF is used as the extraction method.

F.1.3 Limitation of factors

The third choice concerns the limitation of factors. Several rules are used, yet, the Kaiser criterion is mostly applied. The Kaiser criterion entails that while a factor qualifies the condition of having an Eigenvalue higher it should be included in the analysis (Kaiser, 1960; Nunally, 1978).

F.1.4 Determination of factor rotation method

The last step regards the factor rotation and interpretation and involves the decision on which factor rotation method that is applied. Factor rotation transforms the pattern of the factor loadings facilitating the interpretation of the factor structure. Two two rotation techniques are used commonly: (1) orthogonal rotation and (2) oblique rotation. In orthogonal rotation, axes are rotated at a 90-degree angle, such that there is no correlation between the extracted factors, whereas in oblique rotation the factors are correlated (Field, 2000). For this study, first the orthogonal rotation *varimax* was used. This method does not allow a correlation between factors, providing a clear separation of factors, which makes factors easier to interpret. Yet, it may be that dimensions underlying the statements are correlated. Therefore, as an addition to the orthogonal rotation method, the oblique rotation method *direct oblimin* was applied, as this method allows factors to correlate (Field, 2009).

F.2 Performing the factor analyses

The factor analysis is performed with the software package SPSS (IBM, n.d.).

F.2.1 Orthogonal rotation: Elaboration of the varimax rotation process

Now follows a description of the iteration steps that were performed in the factor analysis.

I. After the first iteration step, it is checked if indicators have qualified the criterion considering the communality threshold value of 0,25. Indicator 12 has a communality of 0,276, which is the lowest communality. As all indicators have a high communality, this check does not have to be performed in further iterations. Subsequently, it was checked whether two or more indicators load highly on every factor. The factor loading of an indicator, therefore, has to be higher than 0,5. The first iteration provides a six-factor solution. Yet, the sixth factor does not have any indicator that scores high (>0,5) on the factor. Hence, this factor will be excluded in the second iteration.

II. The second iteration gives a five-factor solution. Again, it is checked whether every factor obtains two or more indicators that load high. Since this is the case, it is checked if the simple structure is approached. A simple structure requires that every indicator loads high (>0,5) on just one factor and low on every other factor (<0,3). Indicator 6 does not load high on a single factor and has a somewhat equal loading on two factors: a factor loading of 0,376 on factor 1 and 0,386 on factor 2 and is therefore deduced in next iteration.

III. The outcome of the third iteration displays that indicator 11 equally loads on factor 1 and 3 and thus is excluded from the analysis.

IV. The fifth factor in the five-factor solution of the fourth iteration does not capture two indicators that load high. For this reason, the next iteration will be forced to a four-factor solution.

V. Likewise, the fourth factor in the fifth iteration does not have two or more indicators that load higher than 0,5 on the factor. The fourth factor is thus removed.

VI. The sixth iteration is forced into three factors. Again, the last factor does not obtain two or more factors with a high factor loading, therefore the third factor is excluded in the seventh iteration.

VII. The two-factor outcome of the seventh iteration indicates that indicator 18 does not load low or high on either the first or the second factor. Hence, indicator 18 is removed from the analysis.

VIII. Indicator 12 does not have high factor loadings on factor 1 or factor 2 after the eighth iteration and is eliminated.

IX. The ninth iteration's results indicate that indicator 19 has a low factor loadings on factor 1 and 2. Hence, this indicator is excluded in the next iteration.

X. Iteration ten gives a two-factor solution in which every indicator has a communality loading greater than 0,3 or 0,5 on one factor and load low (<0,3) on the other factor. A simple structure, therefore, is obtained.

The results display the cumulative percentage of the variance corresponding to the initial Eigenvalues of the factors. This percentage is equal to 40,39%. Furthermore, the results are implying the rotation sums of the squared loadings is equal to 32,44%. The factor results are displayed in Table F.2.

Table F.2: The rotated factor-loading matrix resulting from the varimax rotation

Indicators	Factor	
	1	2
Without a car, I would feel very limited in what I can still do. (2)	0,744	-0,103
I need my car to do all of my activities properly. (3)	0,700	-0,045
A car gives me the feeling of freedom. (1)	0,637	-0,082
I prefer to park my car in front of my house (8)	0,522	0,220
I believe that parking space close to my home increases my home value. (10)	0,504	0,034
I think I could live with a car less or without a car. (5)	-0,481	0,249
I consider the nearest parking space to my house as my own parking space. (7)	0,425	0,150
I drive extra laps until a parking space becomes closer to my house. (9)	0,387	0,206
I think travelling by car should be flexible. (4)	0,348	-0,048
I like to live in a green environment. (15)	0,184	0,635
I like to live in a quiet environment. (16)	0,193	0,608
I believe that a residential environment should be car-free. (20)	-0,333	0,573
I think it is important that children have a place in their living environment where they can play safely. (14)	0,045	0,535
I think cars pollute the street scene. (21)	-0,371	0,495
I think it is important that I have contact with my neighbours. (22)	0,102	0,475
I think my living environment should be pedestrian-friendly. (13)	-0,161	0,342

F.2.2 Oblique rotation: Elaboration of the direct oblimin rotation process

The iteration steps that were performed in the second factor analysis are outlined below:

I. In the first step of the iteration process, it is checked if some indicators have a communality lower than the threshold value of 0,25. Indicator 12 has a communality of 0,276, which is the indicator with the minimum value of the communalities. As all indicators have a high community, this check does not have to be performed in further iterations. Next, it was checked whether two or more indicators load highly on every factor. The factor loading of an indicator, therefore, is required to be higher than 0,5. The first iteration provides a six-factor solution. Again, the sixth factor does not have any indicator that scores very well (>0,5) on the factor, thus, this factor will be excluded in the second iteration.

II. The outcome of the second iteration presents a four-factor solution. It is checked whether every factor has two or more corresponding indicators with high factor loadings. The fourth factor does not meet this criterium and therefore is removed from the analysis.

III. The outcome of the third iteration displays that indicator 21 equally loads on factor 1 and 2, which means that this indicator is excluded from the analysis.

IV. The three-factor solution resulting from the fifth iteration displays that indicator 16 equally loads on factor 2 and 3. This indicator, therefore, is removed from the analysis.

V. Likewise, the fourth factor in the fifth iteration does not have two or more indicators that load higher than 0,5 on the factor. The fourth factor is thus removed.

VI. The sixth iteration results present that the last factor does not obtain two or more factors with a high factor loading, therefore the third factor is excluded in the seventh iteration.

VII. The seventh iteration is therefore forced to a two-factor solution. The results indicate that indicator 18 does not low high on either the first or the second factor. Hence, indicator 19 is removed from the analysis.

VIII. In the eighth iteration, the results in the factor matrix approach a simple structure.

The ultimate results show the cumulative percentage of the variance of the initial Eigenvalues is equal to 43,57% and squared loadings rotation sum equals 34,84%.

Table F.3: The rotated factor-loading matrix resulting from the direct oblimin rotation

Indicators	Factor	
	1	2
Without a car, I would feel very limited in what I can still do. (2)	0,748	-0,136
I need my car to do all of my activities properly. (3)	0,714	-0,067
A car gives me the feeling of freedom. (1)	0,612	-0,053
I believe that parking space close to my home increases my home value. (10)	0,544	0,095
I find going to work without a car a hassle. (6)	0,543	-0,102
I prefer to park my car as close to my house as possible when I have groceries with me.	0,532	0,160
I prefer to park my car in front of my house. (8)	0,505	0,283
I think I could live with a car less or without a car. (5)	-0,483	0,208
I consider the nearest parking space to my house as my own parking space. (7)	0,428	0,188
I drive extra laps until a parking space becomes closer to my house. (9)	0,394	0,246
I think travelling by car should be flexible. (4)	0,367	0,015
I think it is important that children have a place in their living environment where they can play safely. (14)	0,024	0,634
I think it is important that I have contact with my neighbours. (22)	0,063	0,556
I like to live in a green environment. (15)	0,124	0,486
I believe that a residential environment should be car-free. (20)	-0,293	0,427
I enjoy living in an environment where there are always people on the street. (18)	-0,022	0,393
I think my living environment should be pedestrian-friendly. (13)	-0,179	0,370
I think it is important that shops and services are within walking distance of my home. (12)	-0,109	0,324

G

Appendix: Assessing the representativeness of the sample

This appendix will describe the evaluations that are carried out to test if the sample is representative of the population. The characteristics that are used for this assessment are gender, age, educational level, and household income level. For this assessment, first, a straightforward comparison is made between the distributions of socio-demographic characteristics of the sample and the population. Secondly, Chi-square tests were carried out to assess if the frequency distributions considering gender, age, educational level, and household income level in the sample are significantly different from the distributions in the population.

G.1 Comparing frequency distributions

The assessment is performed by comparing the distributions of the sample and population in terms of the socio-demographic characteristics of gender, age, educational level and household income level. Table G.1 represents the frequency distribution of socio-demographic variables in the sample and the population.

Table G. 1: Comparison of the distributions of socio-demographic variables of the sample and the population

Variable		Sample distribution	Population distribution	Difference
Gender (CBS, 2020 - Bevolking, huishoudens..)				
Male		49,8%	49,7%	-0,1%
Female		50,2%	50,3%	0,1%
Age (CBS, 2020 - Bevolking, huishoudens..)				
20-34 years		35,4%	24,3%	-11,1%
35-49 years		30,4%	24,4%	-6,0%
50-65 years		28,0%	26,8%	-1,2%
65+ years		6,2%	24,8%	18,6%
Education				
Lower level education	*Primaryschool, VMBO-G, VMBO-T (mavo), havo, vwo-onderbouw, mbo2, mbo3, mbo 4, havo, vwo*	13,3%	30,1%	16,8%
Middle level education	*hbo, wo- bachelor*	44,7%	36,7%	-8,0%
Higher level education	*wo-master, doctor*	42,0%	31,5%	-10,5%
Net household income class (€/year)				
Below average	€0 – €9.999	5,1%	4,6%	-0,5%
	€10.000 – €19.999	4,7%	24,0%	19,3%
	€20.000 – €29.999	3,5%	32,0%	28,5%
Average	€30.000 – €39.999	9,8%	22,2%	12,4%
	€40.000 – €49.999	30,1%	9,8%	-20,3%
Above average	€50.000 – €100.000	34,8%	6,7%	-28,1%
	€100.000 – €199.999	10,2%	0,6%	-9,6%

At first sight, Table G.1 indicates that the distribution of the categories gender in the sample is more or less equal as the distribution of the population. However, it can be concluded that the frequencies of age, educational level and household income level deviates from the population distributions.

G.2 Performing Chi-square tests

Still, before conclusions can be drawn about the representativeness of the sample, the Chi-square test is used to assess the representativeness of the sample. The Chi-square test can be applied on nominal or categorical variables. Since the variables gender, age, educational level and household income level are nominal or categorical variables, the Chi-square test is an adequate measure for the assessment of the representativeness of the sample. Based on the population distributions the Chi-square test computes per variable the expected counts per category, which are compared with the observed counts in the sample. In case the expected and the observed counts of the socio-demographic characteristics does not deviate significantly, the sample's variables can be considered as representative for the population's variables population (Molin, 2019). However, a condition for performing a Chi-square test is that each expected category should consist of more than 5 observations (Gingrich, 2004). As the categories of the population distributions for these socio-demographic do not contain values of less than 10% (see Section 5.2.1) and the sample consists of 257 observations, the expected number of observations are expected to be higher than 5. This means that Chi-square tests can be performed.

The Chi-square test is calculated with Equation G.1. For each category of the variable the squared difference between the observed number in the sample (O_i) and the expected amount in the sample that is based on the population (E_i) is taken and divided by the expected amount in the sample (E_i). This is done for each category of the variable. The summation of these outcomes results in the Chi-square value presented in Equation G.1.

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i} \quad \text{(G.1)}$$

From Table G.2, G.3, G.4, and G.5 it can be concluded that only the Chi-square test performed for gender is statistically significant. This means that the sample is representative for gender, however, is not representative for the population in terms of age, educational level and household income level. So, correspondingly with the data presented in Table G.1, the Chi-square tests indicated that only gender does not significantly deviate between the sample and the population. The sample may in this research therefore not be considered as representative for the population.

Table G.2: Results of the Chi-square test for gender (CBS Statline, 2020)

	Distribution sample	Distribution population	Observed amount in the sample	Expected amount based on population	Difference
Male	49,8%	49,7%	128	128	0
Female	50,2%	50,3%	129	129	0
				Chi-square value	0
				df	1
				p-value	0,03

Table G.3: Results of the Chi-square test for the level of age (CBS Statline, 2020)

	Distribution sample	Distribution population	Observed amount in the sample	Expected amount based on population	Difference
20-34 years	35,4%	24,3%	91	63	28
35-49 years	30,4%	24,4%	78	63	15
50-65 years	28,0%	26,8%	72	69	3
65+ years	6,2%	24,8%	16	64	-48
				Chi -square value	53
				df	3
				p-value	1

Table G. 4: Results of the Chi-square test for the level of education (CBS, 2020)

	Distribution sample	Distribution population	Observed amount in the sample	Expected amount based on population	Difference
Lower level education	13,3%	30,1%	34	77	-43
Middle level education	44,7%	36,7%	115	94	20
Higher level education	42,0%	31,5%	108	81	27
				Chi-square value	42
				df	3
				p-value	0,95

Table G.5: Results of the Chi-square test for household income level (CBS, 2019b)

	Distribution sample	Distribution population	Observed amount in the sample	Expected amount based on population	Difference
€0 – €9.999	5,1%	4,6%	20	39	9
€10.000 – €19.999	4,7%	24,0%	28	64	21
€20.000 – €29.999	3,5%	32,0%	31	46	5
€30.000 – €39.999	9,8%	22,2%	54	37	8
€40.000 – €49.999	30,1%	9,8%	43	26	11
€50.000 – €100.000	34,8%	6,7%	66	38	22
€100.000 – €199.999	10,2%	0,6%	11	6	5
				Chi-square value	90
				df	7
				p-value	1

G.3 Implications of the representativeness for the choice model estimations

First of all, the sample not being representative of the population indicates that the results should be interpreted with care. Nevertheless, the logit choice models will be estimated based on correlations. As correlations, in general, are insensitive to the representativeness of variable distributions, the differences between the sample and the population do not naturally provide issues for estimating the choice model. On the contrary, the correlations recognised in the sample can still be a decent foundation for estimating the choice model and thus still be sufficient for predicting choice behaviour in the population. However, this may only apply in case one out of the two following conditions are satisfied. The first condition is that each category of the variable should be properly presented. And in case a variable is underrepresented, the second condition should be satisfied. This condition indicates that it should be safeguarded that the drop out of each category of the underrepresented variable should be random. In case the drop out is not random, the choice behaviour of people that took part in the questionnaire while belonging to the underrepresented variable might deviate concerning the people that belong to this category and did not finish the questionnaire (Salkind, 2012).

Considering this data set, the first arrangement is not met for the age class 65 or more years old as this age class represents 6,2% of the sample size. Regarding the household income level, the income levels that have a low composition in the sample do not form an issue, as this variable is coded into three levels (see Section 5.1.1). Besides, determining whether the second prerequisite is met is uncertain. Because the final part of the questionnaire consisted of questions about the socio-demographic characteristics, it is difficult to deduce the characteristics of the people that dropped out early. As it is expected that people that are interested in the topic of study or willing to help a student were more likely to complete the questionnaire. Accordingly, people who are less interested in the topic or find the research method difficult will drop out more often. If this is the case, it can be stated that that the drop out is not random. Which may correspond with the considerable composition of highly educated people that filled in the survey. Nevertheless, correlations can still be estimated, however, behaviour that is observed in the sample may be more severe than the actual behaviour in the population.

G.4 Implications of the representativeness for the willingness to move to a car restricted residential area

Thus, the sample being unrepresentative might not be an issue for determining the willingness to move to a car restricted residential area over a conventional residential area. This is due to estimating choice models is contingent on correlations. Moreover, first, it should be assessed whether the unrepresentative socio-demographic variables are affecting the decision to move to a car restricted area (Molin, 2019). So, in case certain characteristics of the sample have an effect on the willingness to move to a car restricted area, while the sample shows contrasts to the population in these specific characteristics, the estimation results which are based on the sample's behaviour may not be an adequate predictor for the behaviour in the population.

H

Appendix: Estimation of the choice models

The discrete choice models were estimated with the software package PhytonBiogeme (Bierlaire, 2016). First, the MNL model is estimated (Section H.1), thereafter an ML model is estimated (Section H.2). The models will be compared in Section H.3. Lastly, the model fit will be discussed in Section H.4.

H.1 MNL model estimation (3 alternatives)

Initially, an MNL model is developed consisting of three alternatives; two car restricted residential areas and one opt-out alternative (moving to a conventional residential area). The ultimate MNL model is established by repeatedly extending the model specification. The model consisting of only the alternatives' attributes that are altered in the choice experiment is considered the base model. As they represent the attributes of the alternatives, the model will always contain these variables, even if these variables turn out to be insignificant. Subsequently, it is scrutinized if it was possible to enhance the model's goodness-of-fit by including the variables that were also assessed in the survey into the utility functions. These variables are the socio-demographic characteristics, car use, current housing and attitudes concerning car restricted residential areas and car use. The corresponding variables were stepwise added to the model in these specific clusters. The variables that are not significant are excluded from the model. These improvements per model are presented in Table H.1. The process of estimating the final MNL model will be elaborated further in the following paragraphs.

Table H.1: Model fit of estimated MNL models

Model	Number of parameters	Adjusted Rho-square	Final log-likelihood	LRS	Chi-square value (for p=0,01)
Null	0	-	-1.694.060	-	
MNL basic	13	0,187	-1.377.418	633.284	27,69
MNL socio-demographic	19	0,368	-1.374.903	5.030	16,81
MNL car use	27	0,221	-1.319.901	110.004	20,09
MNL current living environment	29	0,234	-1.297.200	45.402	9,21
MNL attitudes	36	0,238	-1.291.681	11.038	18,48
Final MNL	33	0,235	-1.295.196	4.008	13,28

H.1.1 Basic model

Initially, the basic model was estimated, consisting of solely the attributes of the alternatives these include:

- Walking time from the residence to the car
- Type of car parking facility
- Price of parking per month
- Type of building in the residential area
- The liveliness level of the residential area
- Facilities in the residential area
- Green facility level in the residential area

Furthermore, the utility functions of the car restricted residential area alternatives were supported with an alternative specific constant. As presented in Table H.1, the Rho-squared of this model equals 0,187. Compared to the Null-model the increase in model fit was significant at a 99% level of significance.

H.1.2 Socio-demographic variables

Subsequently, socio-demographic variables were included in the model in order to assess if this would increase the goodness-of-fit of the model. Additional to the direct influences these variables could have on people's choices, several interaction effects that were assumed to have an influence were added to model specification. The influences of variables that were examined are displayed in Table H.2.

Table H.2: Estimated influences of socio-demographic variables

	Estimated influence of interaction with	
Socio-demographic variable	Walking time to the car parking in the car restricted residential area	Price of car parking in a car restricted residential area
Age	X	X
Daily occupation	X	X
Household income		X
Household size		
The number of kids in the age class 0-5 years	X	
The number of kids in the age class 6-11 years		
The number of kids in the age class 12-17 years		
Number of people in the household that are infirm or disabled	X	

The insignificant variables were extracted. The model including only the significant variables reports a Rho-square value of 0.368. As displayed in Table H.1, the addition of socio-demographic variables to the base model resulted in an increased model fit. The rise of the goodness-of-fit was significant according to a 99% significance level.

H.1.3 Car use

This was followed by researching whether including variables regarding respondent's car use and car parking customs would be able to improve the model's goodness-of-fit. Again, additional to effects that directly could influence people's choice behaviour, several interaction effects were incorporated in the utility functions. The estimated influences car use variables and their interactions with walking time to the car parking and parking costs are presented in Table H.3.

Table H.3: Estimated influences of car use variables

Car use variable	Estimated influence of interaction with	
	Walking time to the car parking in the car restricted residential area	Price of car parking in a car restricted residential area
The total amount of yearly kilometres travelled by car	X	X
Frequency of car use	X	X
Frequency of car use by night (between 22:00 and 6:00)	X	X
Purpose of the car use	X	X
Current walking time from residence to the car	X	X
Current parking costs arrangement		X
Ownership of private parking		X
Age of the (most used) car	X	X

Again, the insignificant variables were removed, thereafter the results report a value for Rho-square of 0,221. The estimation performance of this model decreased in comparison to the performance of the model including only the socio-demographic variables. However, the final log-likelihood of the model increased whereby, as displayed in Table H.1, the model fit still is increased. Furthermore, Table H.1 presents that the development of the model's fit was significant (99% significance level). Thus, adding the influence of variables of car use is considered to be improving the model.

H.1.4 Current residential environment

Furthermore, it was tested whether including variables regarding the current housing of respondents would enhance the goodness-of-fit. Table H.4 displays the variables that were included in the utility functions of the car restricted residential area alternatives.

Table H.4: Estimated influences of current residential environment variables

Current residential environment variable	Estimated influence of interaction with	
	Walking time to the car parking in the car restricted residential area	Price of car parking in a car restricted residential area
Current living environment	X	X
Current residential area	X	X
Current house ownership		
Plan to move to a new house		

After having removed the insignificant variables, the rho-square value of the adjusted model was 0,234. Furthermore, when considering the LRS (see Table H.1), the increase in model fit, resulting from the adjustments, was significant at the 99% level. The adjustments, therefore, are considered to be enhancing the model.

H.1.5 Perception of (living in) a car restricted residential areas and car use

Lastly, the model was included with perceptions regarding (living in) car restricted residential areas and car use. Table 4.2 in Section 4.2 specifies the statements that were used to measure these attitudes. Additionally, Section 5.4.4 outlined the push and pull factors for living in car restricted areas that were used to measure these perceptions. The variables corresponding to these perceptions that were incorporated the model are presented in Table H.5.

Table H.5: Estimated influences of socio-demographic variables

Attitudinal variable	Estimated influence of interaction with	
	Walking time to the car parking in the car restricted residential area	Price of car parking in a car restricted residential area
Car-oriented perspective	X	X
Care for the quality of the living environment	X	X
Push and pull *factors car restricted residential areas*		
Push and pull factor bicycle facilities		
Push and pull factor walking facilities		
Push and pull factor green facilities		
Push and pull factor parking accessibility		
Push and pull factor parking availability		
Push and pull factor amount of traffic		
Push and pull factor traffic nuisance		
Push and pull factor traffic safety		

The Rho-square value after removing the insignificant variables was 0,235. Furthermore, comparing the final Log-likelihood value of the ultimate model to the prior estimated model including socio-demographic, car use and current housing variables the increase in goodness-of-fit was significant (99% significance level) (Table H.1). The utility functions of the final MNL model is presented in Equation H.1.

$$
\begin{aligned}
Ucarfree = {} & ASC_{carfree} + \beta_{Time} * Time + \beta_{Type_{eff1}} * Type_{eff1} + \beta_{Type_{eff2}} * Type_{eff2} + \beta_{Price} \\
& * Price + \beta_{Building_{eff1}} * Building_{eff1} + \beta_{Building_{eff2}} * Building_{eff2} + \beta_{Live_{eff1}} \\
& * Live_{eff1} + \beta_{Live_{eff2}} * Live_{eff2} + \beta_{Facilities_{eff1}} * Facilities_{eff1} + \beta_{Facilities_{eff2}} \\
& * Facilities_{eff2} + \beta_{Green_{eff1}} * Green_{eff1} + \beta_{Green_{eff2}} * Green_{eff2} + \beta_{householdsize} \\
& * householdsize + \beta_{interaction_{Time*housholdsize}} * hhsize * Time \\
& + Beta_{interaction_{Time*kidsyoung}} * kids_{young} * Time + Beta_{car\ parking\ private_{eff2}} \\
& * car\ parking\ private_{eff2} + \beta_{car\ use\ eff1} * car\ use_{eff1} + \beta_{car\ use\ eff2} * car\ use_{eff2} \\
& + \beta_{car\ purpose\ eff1} * car\ use_{eff1} + \beta_{current\ car\ parking\ costs\ eff2} \\
& * current\ car\ parking\ costs_{eff2} + \beta_{interaction_{Price*current\ walking\ time}} * c_{time\ parking} \\
& * Price + \beta_{interaction_{Price*car\ old\ years}} * car_{oldyears} * Price \\
& + \beta_{interaction_{Price*current\ parking\ costs}} * car_{parking\ costs_{eff1}} * Price \\
& + \beta_{interaction_{Price*parking\ costs_{eff2}}} * car_{parking\ costs_{eff2}} * Price + \beta_{residential\ area_{eff1}} \\
& * residential\ area_{eff1} + \beta_{house\ env_{eff2}} * house\ env_{eff2} + \beta_{house\ own} * house\ own \\
& + \beta_{planmove_{eff1}} * plan\ move_{eff2} + \beta_{planmove_{eff2}} * plan\ move_{eff2} + \beta_{perception_{factor2}} \\
& * car\ perception_{factor2} + \beta_{interaction_{Time*perception_{factor2}}} * car\ perception_{factor2} \\
& * Time + \beta_{interaction_{Price*perception_{factor2}}} * car\ perception_{factor2} * Price
\end{aligned}
$$

(H.1)

H.2 ML model estimation (3 alternatives)

In addition to the estimation of the MNL model, a Mixed Logit (ML) model was estimated. The estimation process was performed with the same stepwise approach as the estimation of the MNL model. For the estimation of the ML model, Monte-Carlo simulation was applied, which uses draws taken from a normal distribution. In the estimation process of the ML model, the number of draws was repeatedly increased until the estimation results (parameter estimates, significance, Rho-square value and final Log-likelihood) became stable. Again, it was tested whether adjusting the model would lead to an increased model fit, if this was not the case then the adjustments should be considered not to improve the model and therefore should be removed from the model. First, nesting effects were captured in the model, meaning that the model takes into account the similarities between alternatives. Secondly, panel effects were included, which implies that the model considers that individuals made multiple decisions and that correlation between these decisions may exist. Subsequently, the possibility of people having different preferences regarding design variables were included, thereby allowing random taste heterogeneity among respondents. This last model was supplemented with the significant socio-demographic, car use, current residential environment and attitudinal variables of the MNL model. The model fits of each estimated ML model are outlined in Table H.6. The table indicates that capturing taste heterogeneity among respondents and the panel effects contributes most to the model fit of the ML model. The estimation results the ML model are displayed in Table H.6. The steps which are taken to estimate the ML model are outlined in the following paragraphs.

Table H.6: Model fit of estimated ML models

Model	Number of parameters	Adjusted Rho-square	Final log-likelihood	LRS	Chi-square value (for p=0,01)
Null model	0		-1.694.060		
MNL Basic	13	0,187	-1.377.418	633284	27,69
ML A - 100 Draws	14	0,162	-1.377.367	102	6,63
ML A - 200 Draws	14	0,162	-1.377.409		
ML A - 400 Draws	14	0,162	-1.377.416		
ML A - 800 Draws	0	0	0		
ML B - 100 Draws	14	0,206	-1.058.335	638166	6,63
ML B - 200 Draws	14	0,205	-1.059.133		
ML B - 400 Draws	14	0,205	-1.059.306		
ML B - 800 Draws	14	0,205	-1.059.273		
ML C - 100 Draws	26	0,639	-1.055.213		
ML C - 200 Draws	26	0,558	-1.037.284	3.122	26,22
ML C - 400 Draws	26	0,47	-1.045.911		
ML C - Sign I - 100 Draws	18	0,231	-1.046.519		
ML C - Sign I - 200 Draws	18	0,231	-1.043.092	15.243	13,28
ML C - Sign I - 400 Draws	18	0,206	-1.049.061		
ML C - Sign I - 800 Draws	18	0,205	-1.053.087		
ML C - extended - 100 Draws	46	0,546	-1.003.635	39.457	48,28
ML C - extended - 200 Draws	46	0,546	-1.004.226		
ML C - extended - 400 Draws	46	0,521	-1.006.573		
ML C extended SIGN I - 100 Draws	28	0,258	-1.011.915		
ML C extended SIGN I - 200 Draws	28	0,264	-1.015.514		
ML C extended SIGN I - 400 Draws	28	0,244	-1.016.894		
ML C extended SIGN I - 800 Draws	28	0,249	-1.012.020	31.072	23,21
ML C extended SIGN II - 100 Draws	26	0,256	-1.013.245		
ML C extended SIGN II - 200 Draws	26	0,265	-1.015.622	27.470	20,09
ML C extended SIGN II - 400 Draws	26	0,242	-1.018.438		
ML C extended SIGN II - 800 Draws	26	0,243	-1.020.665		

H.2.1 Nesting effects

Initially, the basic model (with only the attributes of the alternatives) that was used in the MNL estimation process, was set as the foundation for the ML model estimations. As in the estimated MNL models, the utility functions of the car restricted residential area alternatives were expanded with an ASC. Moreover, the utility functions of the car restricted residential area alternatives were expanded with a supplementary error term that captured the nesting effects. This error component expresses the utility of the unobserved factors that are similar for the car restricted residential area alternatives. The results of the model became stable at 200 draws and the final log-likelihood of the estimated model was highest using 100 draws. 0,162 is the adjusted Rho-square value that is reported. As displayed in Table H.6, this value is minor to the Rho-square value of the basic MNL model, yet the value of the final log-likelihood increased. Resulting from the LRS presented in Table H.6, the model fit of the nested ML model improved with 99% certainty in comparison to the basic MNL model.

H.2.2 Panel effects

Through capturing panel effects, the former model was enhanced. It was tested whether seizing the correlation of the choices of the same individual would improve the model fit. The Rho-square value of the enhanced model was 0,206. As presented in Table H.6, the LRS value indicates that the addition of panel effects did improve the model fit regarding a 99% significance level, and therefore capturing panel affects is recognized to improve the ML model. Again, the results of the estimation became stable using 100 draws.

H.2.3 Random taste heterogeneity

Subsequently, it was analysed if taste heterogeneity existed among respondents for the design variables of car restricted residential areas. The model, therefore, was extended with random parameters for the attributes. The insignificant variables were removed from the model specification, which resulted in a Rho-square value of 0,219. As compared to the ML model including the attributes, nesting effects and panel effects, the model fit increased according to the 99% level of significance. Thus, capturing random taste heterogeneity in the ML model is considered to improve the model.

H.2.4 Socio-demographic variables, car use, current living environment and attitude effects

Since an MNL model overlooks the possibility that correlation occurs between a sequence of choices that are made by an individual, the model assigns too much certainty to the estimated parameters, resulting in an underestimation of the standard error of parameters. Therefore, estimated parameters that are significant according to the results of the MNL model may turn out not to be significant when estimating an ML model. Hence, the ML model is extended with the significant variables of the final MNL model. After excluding the insignificant parameters from the model, the adjusted Rho-square value was 0,265. With regard to the ML model without the additional characteristics, the model fit of the final estimated model increased at the 99% significance level. Therefore, the supplementation of the additional variables is considered to be an improvement of the model.

The estimation results of the final ML model are displayed in H.7 and the utility functions of the final ML model is expressed in Equation H.2.

$$
\begin{aligned}
Ucarfree = {} & ASC_{carfree} + \upsilon_{carfree} + \beta_{Time} * Time + \beta_{Type_{eff1}} * Type_{eff1} + \beta_{Type_{eff2}} * Type_{eff2} \\
& + \beta_{Price} * Price + \beta_{Building_{eff1}} * Building_{eff1} + \beta_{Building_{eff2}} * Building_{eff2} \\
& + \beta_{Live_{eff1}} * Live_{eff1} + \beta_{Live_{eff2}} * Live_{eff2} + \beta_{Facilities_{eff1}} * Facilities_{eff1} \\
& + \beta_{Facilities_{eff2}} * Facilities_{eff2} + \beta_{Green_{eff1}} * Green_{eff1} + \beta_{Green_{eff2}} * Green_{eff2} \\
& + \beta_{interaction_{Time*housholdsize}} * hhsize * Time + Beta_{interaction_{Time*kidsyoung}} * kids_{young} \\
& * Time + \beta_{car\ use\ _{eff1}} * car\ use_{eff1} + \beta_{car\ purpose\ _{eff1}} * car\ use_{eff1} \\
& + \beta_{interaction_{Price*current\ walking\ time}} * c_{time\ parking} * Price \\
& + \beta_{interaction_{Price*current\ parking\ costs}} * car_{parking\ costs_{eff1}} * Price \\
& + \beta_{interaction_{Price*parking\ costs_{eff2}}} * car_{parking\ costs_{eff2}} * Price + \beta_{house\ own} * house\ own
\end{aligned}
\tag{H.2}
$$

Where:

$\upsilon_{carfree} \sim N\,(ASC_{carfree}, \sigma_{\upsilon_{carfree}})$

$\beta_{Time} \sim N\,(\beta_{Time}, \sigma_{\beta_{Time}})$

$\beta_{Building_{eff1}} \sim N\,(\beta_{Building_{eff1}}, \sigma_{\beta_{Building_{eff1}}})$

$\beta_{Live_{eff1}} \sim N\,(\beta_{Live_{eff1}}, \sigma_{\beta_{Live_{eff1}}})$

$\beta_{Green_{eff2}} \sim N\,(\beta_{Green_{eff2}}, \sigma_{\beta_{Green_{eff2}}})$

Table H.7: Results of the MNL- and ML model (3 alternatives)

Variable	MNL Model				ML model			
	Value	Standard error	t-test	p-value	Value	Standard error	t-test	p-value
Alternative specific constant car restricted residential area	-1,34	0,273	-4,92	0,00	-2,16	0,404	-5,34	0
Attributes of the alternatives								
Walking time to the car parking facility	0,103	0,0367	2,81	0,00	0,0787	0,0257	3,06	0,00
Type of car parking facility								
Private parking space in a parking garage (1)	-0,184	0,0849	-2,17	0,03	-0,214	0,112	-1,91	0,06
Public parking garage (2)	0,0426	0,0727	0,59	0,56*	0,191	0,0988	1,94	0,05
Monthly parking costs	0,00148	0,000785	1,88	0,06*	0,00285	0,00102	2,79	0,01
Type of building in the car restricted residential environment								
Mainly high-rise building (1)	0,107	0,104	1,03	0,30*	-0,0173	0,0756	-0,23	0,82
Mainly low-rise building (2)	-0,309	0,102	-3,04	0,00	-0,223	0,142	-1,56	0,12
Liveliness level in the car restricted residential environment								
Hardly people on the street (1)	-0,352	0,0893	-3,94	0,00	-0,221	0,0616	-3,59	0,00
Lively street scene with residents (2)	-0,0296	0,0781	-0,38	0,70*	0,0298	0,0947	0,32	0,75
Facilities in the car restricted residential environment								
Only a supermarket (1)	0,162	0,102	1,58	0,11*	0,338	0,143	2,37	0,02
A simple range of facilities (2)	-0,326	0,0922	-3,53	0,00	-0,288	0,127	-2,28	0,02
Green facility level in the car restricted residential environment								
Small parks spread through the neighbourhood (1)	0,208	0,0736	2,83	0,00	0,154	0,0973	1,58	0,11
One big central park (2)	-0,316	0,0837	-3,78	0,00	-0,199	0,0614	-3,23	0,00
Socio-demographic variables								
Household size	0,194	0,0726	2,67	0,01				
Interaction between Walking time to the car parking facility and household size	-0,0501	0,013	-3,84	0,00	-0,0776	0,0189	-4,11	0,00
Interaction between Walking time to the car parking facility and kids between 0 – 5 years	0,0543	0,0188	2,89	0,00	0,139	0,0378	3,69	0,00
Car use								
Frequency of car use								
Daily base (1)	-0,571	0,153	-3,73	0,00	-1,28	0,457	-2,8	0,01
Weekly (2)	-0,295	0,137	-2,16	0,03				
Purpose of car use								
Private (1)	-0,314	0,0656	-4,79	0,00	-0,66	0,248	-2,66	0,01
Current walking time to the car								
Interaction between Monthly parking costs and Current walking time car to the car	-0,00202	0,000329	-6,15	0,00	-0,00214	0,000487	-4,39	0,00

Variable	MNL Model				ML model			
	Value	Standard error	t-test	p-value	Value	Standard error	t-test	p-value
Age of the car								
Interaction between Monthly parking costs and Age of the car	0,000127	3,82E-05	3,33	0,00				
Current parking paying arrangement								
PC2 (Bought a car parking space)	-0,934	0,14	-6,70	0,00				
Interaction between Monthly parking costs and Pays monthly for car parking (1)	-0,00263	0,000629	-4,18	0,00	-0,0024	0,000893	-2,69	0,01
Interaction between Monthly parking costs and Bought a car parking space (2)	0,00524	0,000842	6,23	0,00	0,00477	0,00109	4,37	0,00
Private parking ownership								
Private garage or driveway (2)	-0,367	0,106	-3,45	0,00				
Current residential environment								
Living environment								
Off centre city (2)	-0,399	0,116	-3,45	0,00				
Residential area								
G4 citiies (1)	0,227	0,0885	2,56	0,01				
House ownership	-0,365	0,0853	-4,29	0,00	-0,636	0,289	-2,2	0,03
Plan to move to a new house								
Yes, within 1,5 year from now (1)	-0,205	0,0923	-2,23	0,03				
Yes, in 1,5 to 5 years from now (2)	0,302	0,11	2,76	0,01				
Attitudes								
Attitudinal factors								
Quiet living attitude (factor 2)	-0,00384	0,00141	-2,73	0,01				
Interaction between Monthly parking costs and Quiet living attitude (factor 2)	1,20E-05	5,41E-06	2,21	0,03				
Interaction between Walking time to the car parking facility and Quiet living attitude (factor 2)	0,000566	0,00019	2,98	0,00				
Sigmas								
Alternative specific constant car restricted residential area					4,02	0,373	10,77	0,00
Walking time to the car parking facility					0,0756	0,0242	3,12	0,00
Mainly high-rise building (1)					-0,706	0,163	-4,34	0,00
Hardly people on the street (1)					0,437	0,141	3,1	0,00
One big central park (2)					0,345	0,119	2,9	0,00
Log-likelihood (LL)	-1.295.196				-1015.662			
Adjusted Rho-square value	0.235				0.265			
* Not significant at 95% significance level								

H.3 MNL and ML model comparison (3 alternatives)

A comparison of the results of the MNL model to the results of the ML model indicate that multiple parameters estimates that were significant when estimating an MNL model, were insignificant in the estimation ML model. This may be the result of the assumption of the MNL model which presumes the choices made by the same individual over time not to be correlated. This assumption induces that every observation in the data set contributes an equal amount of knowledge for estimating the parameters, while in fact, the sequence of choices made by the same individual are likely to be correlated and therefore should be considered as such. This assumption, therefore, is likely to result in an underestimation of a parameter's standard error and an overestimation of the parameter's corresponding t-values. This can cause parameters to become significant while actually not being significant. This underestimation of standard errors and overestimation of t-values applies as well for the assumption of the MNL model which assumes tastes are the same within (segments) of the population.

Furthermore, Table H.7 indicates the Rho-square value of the ML model to be higher compared to the Rho-square value of the MNL model. Furthermore, the Log-likelihood value of the ML model, in comparison with the Log-likelihood value of the MNL model, increased. However, next to looking at the plain results, it should be tested whether the model fit of the ML panel significantly increased to the model fit of the MNL model. Since the models are non-nested, for this assessment the Ben-Akiva and Swait test is used. This test calculates the probability that the ML model, even though having an increased model fit for the sample, is a less adequate model to predict behaviour in the population. The test indicates the likelihood of the MNL model being superior for estimating behaviour in the population, even though the ML model fits the sample data better. The results show that this likelihood is smaller than 0,00%, which indicates the increase in model fit is significant. For this reason, only the outcome of the ML model will be interpreted and will be used to report the research questions.

H.4 Goodness-of-fit (3 alternatives)

The final Log-likelihood value of the ML model indicated in Table H.7 equals -1015,662, while the initial Log-likelihood value of the model was -1382,528. The adjusted Rho-square value of the model is 0,265, which indicates that the model is able to explain 26,5% of the initial uncertainty. This means that compared to having no understanding of car owners' choice behaviour considering the willingness to move to a car restricted residential area, the model is able to clarify 26,5% of the choice behaviour. Thus, capturing panel effects and random taste heterogeneity did increase the model fit slightly in comparison to the MNL model, implying that choices made by the same individual are correlated and at the same time tastes vary across individuals. Yet, at the same time, this indicates that the choice behaviour of respondents is dependent on more than the observed variables only.

H.5 Model estimations (2 alternatives)

The model results of the MNL and ML models modelling the choice between only the two car restricted residential areas are presented in Table H.8. Although the values of the final-likelihoods of these models are lower compared to the models estimating the choices between 3 alternatives, the Rho-square values indicate that the exploratory power of these models is lower than the models including 3 alternatives. Therefore, it can be concluded that the last two models are not better in explaining the choice behaviour of the car owners than the models including 3 alternatives.

Table H.8: Results of the MNL- and ML model (2 alternatives)

Variable	MNL Model				ML model			
	Value	Standard error	t-test	p-value	Value	Standard error	t-test	p-value
Attributes of the alternatives								
Walking time to the car parking facility	0.105	0.0325	3.22	0.00	0.00920	0.0219	0.42	0.68*
Type of car parking facility								
Private parking space in a parking garage (1)	-0.0989	0.0890	-1.11	0.27*	-0.120	0.0897	-1.33	0.18*
Public parking garage (2)	0.186	0.0643	2.89	0.00	0.200	0.0647	3.09	0.00
Monthly parking costs	0.000520	0.000631	0.82	0.41*	-0.00155	0.000333	-4.67	0.00
Type of building in the car restricted residential environment								
Mainly high-rise building (1)	0.0106	0.115	0.09	0.93*	0.0173	0.114	0.15	0.88*
Mainly low-rise building (2)	-0.235	0.123	-1.92	0.06*	-0.264	0.123	-2.16	0.03
Liveliness level in the car restricted residential environment								
Hardly people on the street (1)	-0.431	0.0869	-4.96	0.00	-0.435	0.0877	-4.96	0.00
Lively street scene with residents (2)	0.00967	0.0689	0.14	0.89*	0.0132	0.0690	0.19	0.85*
Facilities in the car restricted residential environment								
Only a supermarket (1)	0.441	0.127	3.47	0.00	0.476	0.128	3.73	0.00
A simple range of facilities (2)	-0.417	0.101	-4.11	0.00	-0.209	0.0510	-4.09	0.00
Green facility level in the car restricted residential environment								
Small parks spread through the neighbourhood (1)	0.0536	0.0747	0.72	0.47*	0.0713	0.0739	0.97	0.33*
One big central park (2)	-0.334	0.0908	-3.68	0.00	-0.377	0.0900	-4.19	0.00
Socio-demographic variables								
Household composition								
Interaction between walking time to the car parking facility and household size	-0.0320	0.00889	-3.61	0.00				
Interaction between walking time to the car parking facility and children between 0 – 5 years	0.0429	0.0179	2.40	0.02				
Interaction between monthly car parking costs and household size								
Car use								
Current walking time to the car								
Interaction between walking time to the car parking facility and current walking time to the car	-0.0193	0.00745	-2.59	0.01				
Interaction between monthly car parking costs and current walking time to the car	-0.00142	0.000292	-4.87	0.00				

Variable	MNL Model				ML model			
	Value	Standard error	t-test	p-value	Value	Standard error	t-test	p-value
Current parking paying arrangement								
Interaction between Price and Pays monthly for car parking (1)	-0.00131	0.000499	-2.62	0.01	-0,0024	0,000893	-2,69	0,01
Interaction between Price and Bought a car parking space (2)	0.00244	0.000616	3.96	0.00	0,00477	0,00109	4,37	0,00
The total amount of yearly kilometres travelled by car								
Below average (0-9.999)	0.000799	0.000283	2.82	0.00				
Sigmas								
Sigma – A simple range of facilities (2)					0.265	0.0980	-2.70	0.01
Log-likelihood (LL)	-916.984				-950.627			
Adjusted Rho-square value	0.142				0.140			
* Not significant at 95% significance level								

I

Appendix: Choice model results

I.1 Alternative specific constant car restricted residential area

The value of the constant of the car restricted residential areas is -2,16. The constant captures the total (average) utility associated with variables other than the observed variables, such as the hassle that is associated with remote car parking or scepticism about the idea of (living in) a car restricted residential area.

Furthermore, the parameter estimated is significant (p-value of 0,00), which reveals an average willingness to move to a conventional residential area. The value of sigma of the car restricted residential area constant is 4,02, expresses a high degree of unobserved taste for car restricted residential areas. The probability density function of the car restricted residential area constant is illustrated in Figure I.1. The probability density function indicates that there is large heterogeneity in the amount of utility that respondents identify to car restricted residential areas which cannot be explained by observed variables. This unobserved preference varies between utility values of three and five.

Figure I.1: Probability density function of the alternative specific constant for car restricted residential areas

I.2 Design variables of car restricted residential areas

I.2.1 Walking time to the car parking facility

Considering the design variable walking time to the car parking facility, the sample's average taste for the walking time between their residence and car is slightly positive (0,0787). The parameter estimate is also significant, which indicates that on average, for people that chose to move to a car restricted area, the walking time to the car parking facilities does not matter and that in fact on average people derive utility from an increase in walking time to the car. Figure I.2 shows the utility increase per minute increase in walking time to the car. The value of sigma is 0,0756, indicating a small degree of unobserved taste variation for walking time to the car parking facility. Figure I.3 shows the probability density function of the walking time to the car parking facility. The figure illustrates there is a minor unobserved preference for a minute walking time to the car parking facility.

Figure I.2: Utility contribution per minute walking time to the car parking facility

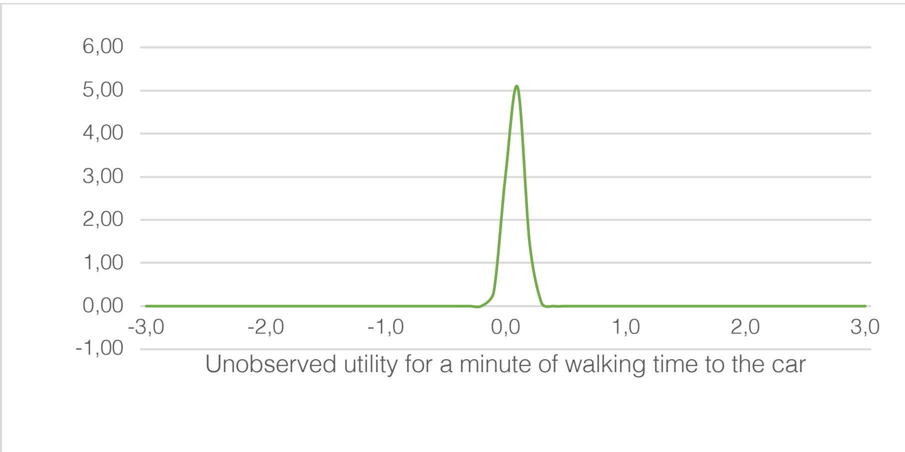


Figure I.3: Probability density function of β for the walking time to the car parking facility

I.2.2 Type of car parking facility

The parameter estimates of the type of car parking facility are both not appreciated significantly different from the average utility people associated with the type of parking. As indicated in Figure I.4 private car parking space in a parking garage is valued negatively (-0,214) and a public parking garage is valued positively (0,191). This result is remarkable as it was expected that people would valuate a private parking space higher than a public parking garage in which no specific parking space is pre-reserved.

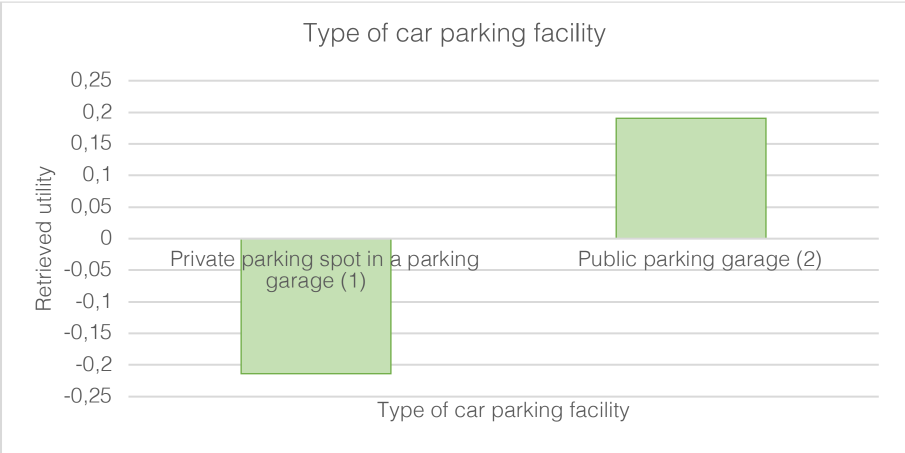


Figure I.4: Utility contributions per the levels of Types of car parking facility

I.2.3 Monthly parking costs

The monthly parking cost parameter was valued slightly positive (0,0028), moreover, the parameter estimate is significant. This indicates that there is an average taste for parking costs. Figure I.5 illustrates the utility contribution per monthly parking price. An increase in parking price per month increases the average utility retrieved by this attribute. This is unexpected as generally, people minimalise their costs. However, a high composition of the sample indicated to pay monthly for parking their car or did buy a car parking, thus may, therefore, be used to pay for parking their car.

Figure I.5: Utility contributions per monthly parking price

I.2.4 Type of building in the car restricted residential environment

The two levels of the type of building in the car restricted residential environment were not assessed to be significantly different from the average utility which people retrieve from the type of building in the residential area. Figure I.6 indicates that on average mainly low-rise building was valued more negatively (-0,223) than mainly high-rise building (-0,0173). Probably people that choose to move to a car restricted residential area live in a high-density building environment, and thus value mainly high-rise building less negatively than mainly low-rise building. Yet the sigma value of mainly high rise building of -0,706 indicates that there is a high degree of unobserved taste variation for high-rise buildings in a car restricted residential area. Figure I.7 illustrates the probability density function of the type of building. It shows that on average there is a negative unobserved utility associated with mainly high-rise buildings that variate between -1 and 0.

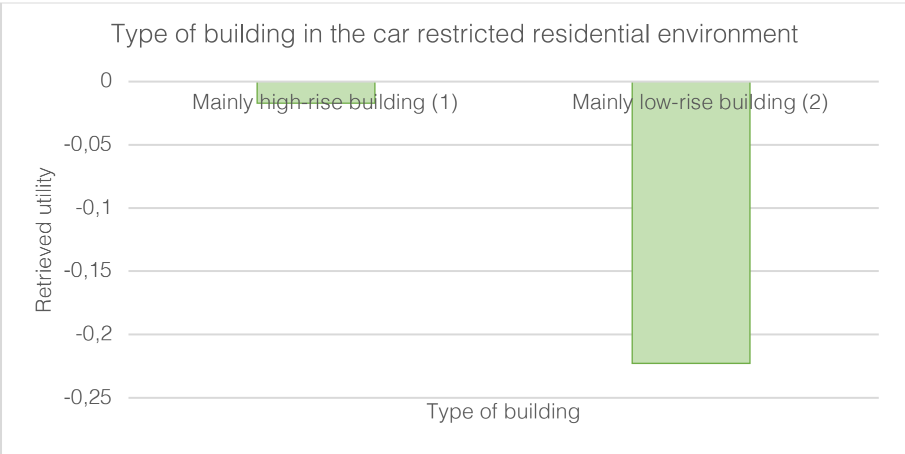


Figure I.6: Utility contributions per the levels of Types building in the car restricted residential environment

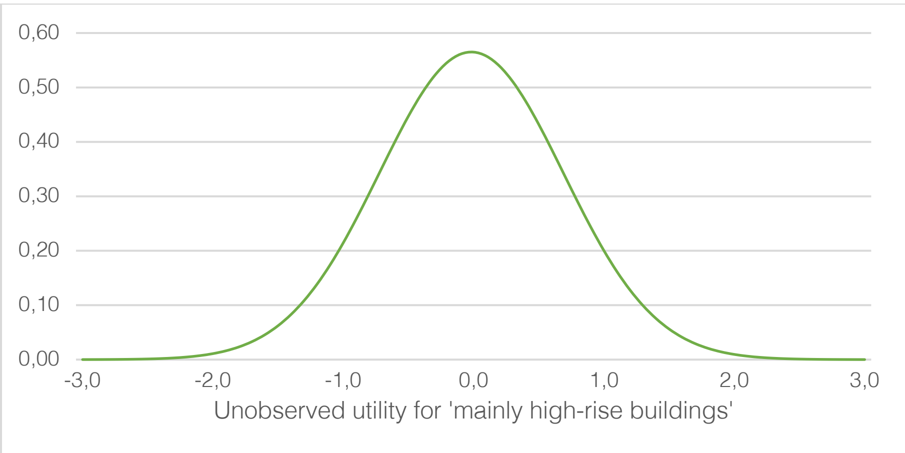


Figure I.7: Probability density function of the β for mainly high-rise building

I.2.5 Liveliness level in the car restricted residential environment

Considering the liveliness level in the car restricted residential environment, as indicated by Figure I.8, on average hardly people on the street was weighted negatively (-0,221) and a lively street scene with residents positively (0,0298). Nevertheless, a lively street scene with residents was not appreciated significantly different from the average utility associated with the overall liveliness level in the car restricted residential area, meaning that there was only an average negative taste for the liveliness level hardly people on the street. Furthermore, there is significant heterogeneity in taste for the liveliness level hardly people on the streets. The sigma value of this liveliness level is 0,437, indicating that there was a degree of unobserved taste variation for hardy people on the streets. In Figure I.9 the probability density function is provided. The illustration of the probability density function shows that the unobserved utility that is associated with the liveliness level of hardly having people on the street varies between zero and one.

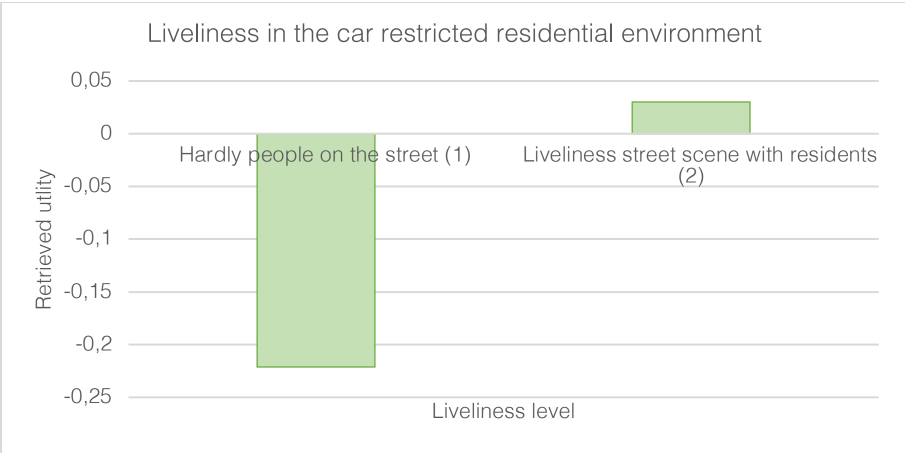


Figure I.8: Utility contributions per levels of Liveliness in the car restricted residential environment

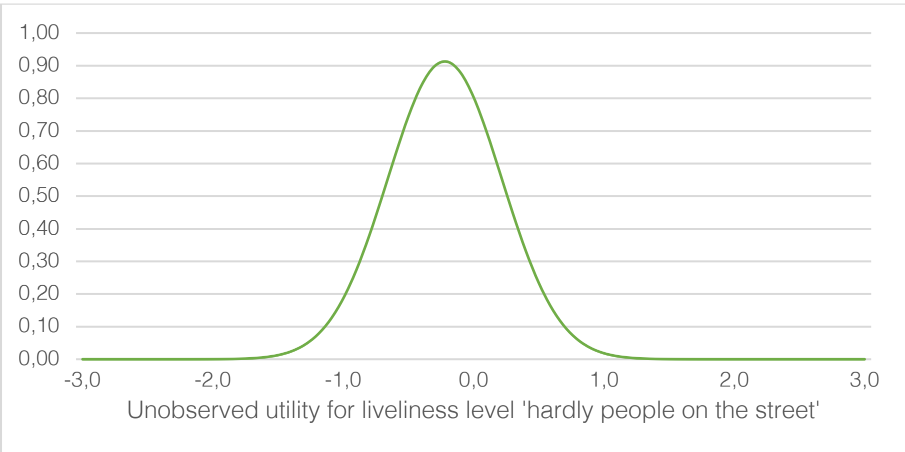


Figure I.9: Probability density function of the β for liveliness level hardly people on the street

I.2.6 Facilities in the car restricted residential environment

With regard to the facilities that are offered in the car restricted neighbourhood, the estimated parameter value of only having a supermarket is 0,338 and the parameter value of a simple range of facilities is equal to -0,288. Thus, people valued only having a supermarket positively while a neighbourhood consisting of a simple range of facilities is not preferred. It was expected that people would prefer having a broader range of facilities over only a supermarket. However, it may be that car owners are already used to not having more than just a supermarket within the residential area. Figure I.10 illustrates the retrieved utility per facility level in the car restricted residential area.

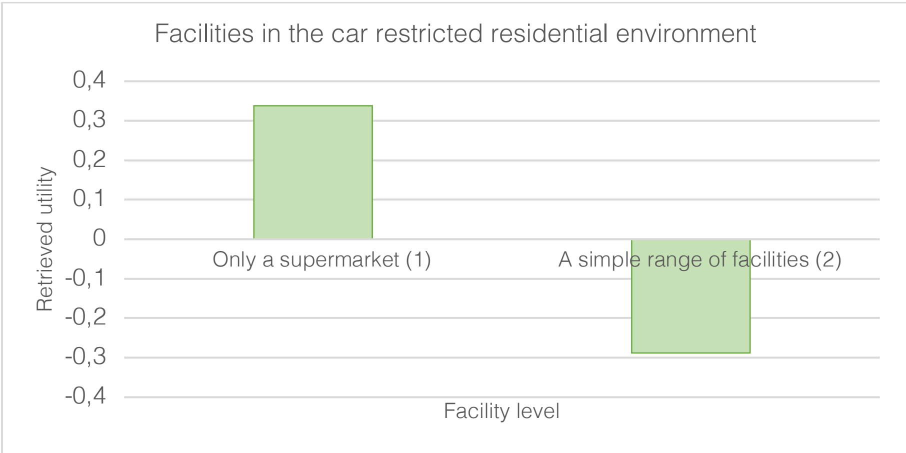


Figure I.10: Utility contributions per facility level in the car restricted residential environment

I.2.7 Green facility in the car restricted residential environment

With regard to the level of green facilities in the car restricted residential areas, Figure I.11 indicates that small parks spread through the neighbourhood are preferred (0,154) and one big central park is not preferred (-0,199). Yet only the parameter estimate for one big central park turned out to deviate significantly from the average utility associated with the level of green areas in the residential area. Thus, on average, there is only a negative taste for one big central park. This may result from the expectation that the space created by restricting cars from the streets may be filled with green space and therefore only including one big park in the residential environment is considered negatively.

The significant sigma parameter estimate of one big central park expresses a degree of unobserved taste variation for the green facility-level one big central park. However, as this value is 0,0756, the degree of variation is only small. Figure I.12 illustrates the probability density function. The projection of this function indicates that the observed utility that is associated with a neighbourhood that consists of one big central park is positive and varies between zero and one.

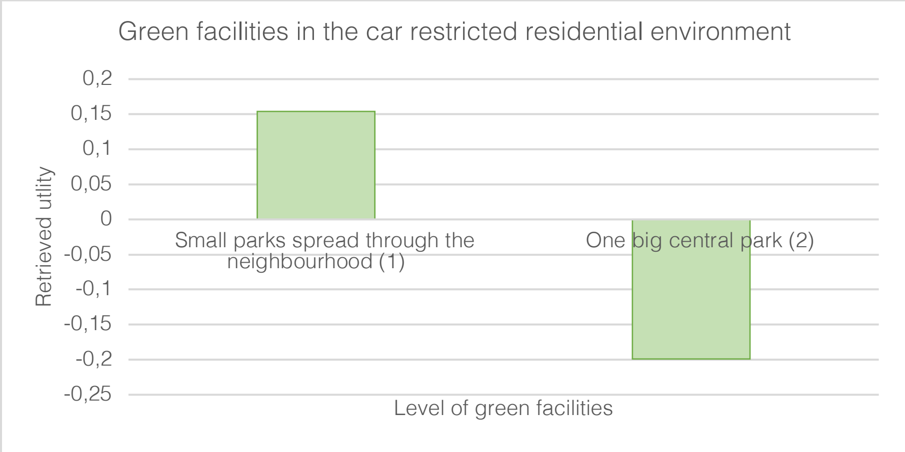


Figure I.11: Utility contributions per levels of green facilities in the car restricted residential environment

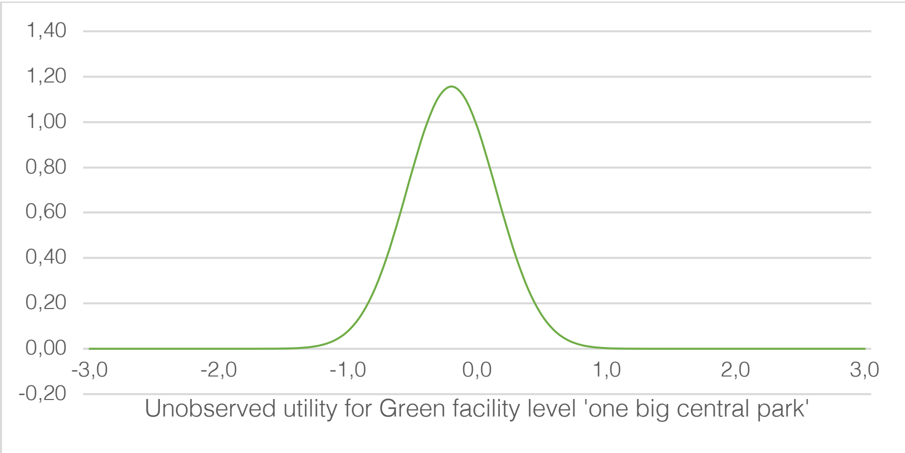


Figure I.12: Probability density function of the β for one big central park in the car restricted residential environment

I.3 The effect of socio-demographic variables, car use, current living environment and attitudes

Next to the design variables of the car restricted residential area, the ML model was enhanced with socio-demographic variables and variables indicating car use, current residential environment, and attitudes. This section describes the effects of these variables on the utility retrieved from car restricted residential areas.

I.3.1 Socio-demographic variables

Only household size and number of children between 0–5 years old were found to have a significant effect on the utility associated with car restricted residential areas. The parameter value of the interaction between walking time to the car parking facilities and household size is -0,776. This indicates that the bigger the size of the household and the longer walking time to the car parking, the less utility is associated with living in a car restricted residential area. This may be the result of people with bigger household sizes that find remote parking more hassle. Figure I.13 illustrates the effect of household size together with walking time to the car parking facility on utility contributions. Nevertheless, it should be stated that, as indicated in Section 5.3, the household size of the sample deviates from the size of households in the population. For this reason, the influence of the interaction between household size and minutes of walking time to the car parking facility on the utility of car restricted residential area may not be a good predictor for the population. The sample, after all, consists of a high composition of more person households in comparison to the population. Which may distort the influence of household size on the retrieved disutility for remote parking.

The parameter value of interaction between walking time to the car parking facility and the number of children between zero and five years old is 0,139. This indicates that households with one or more children in the age category zero to five prefer to walk further to their car. This is in contrast to the parameter value of the interaction between walking time to the car parking and household size. However, it may be that parents of children in this age category associate the walking time to the car with the range in which there is no car activity from their residence. Meaning that the walking time to the car parking facility implicitly is associated with their children that can play safely on the streets. The effect of the number of children between zero and five years old and walking time to the car to the utility contributions is illustrated in Figure I.14.

Figure I.13: Utility contributions of the interaction between walking time to the car parking facility and household size

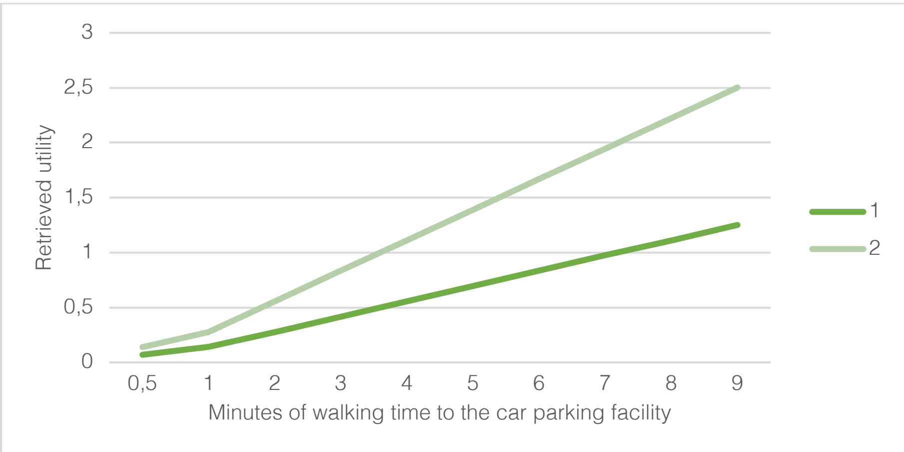


Figure I.14: Utility contributions of the interaction between walking time to the car parking facility and the number of children between 0-5 years old

I.3.2 Car use

Of the variables representing car use which were supplemented to the ML model, several were significant. First, the results indicate the frequency of car use to have a significant effect on the total utility associated with moving to a car restricted residential area. The results of the ML model indicate that people who use their car daily on average associate negative utility from living in a car restricted area (-1,28). This may be the result of people that use the car daily do perceive more hinder from parking their car remote as walking to their car this will take on more time of their daily routine. Furthermore, the negative parameter for the level of the purpose of car use indicates that people who use their car for only private purposes on average do not prefer living in a car restricted residential area (-0,66). This may be caused by the feeling that parking a car remotely, and thus the time it takes to walk to the car is associated with the time that could be spent on private activities. The utility contribution of daily car use and using the car for private purposes is illustrated in Figure I.15 and Figure I.16.

Additionally, the results indicate that there is a significant interaction between current walking time to the car and the monthly parking price. Implying that the time that people currently walk to their car does influence the price people are willing to pay monthly for parking their car while living in a car restricted residential area. The value of -0,00214 of the parameter estimate indicates that people who currently have a short walking time between their residence and their car do not want to spend money for parking their car in car restricted residential areas. Figure I.17 illustrates the effect of this interaction on the utility contribution.

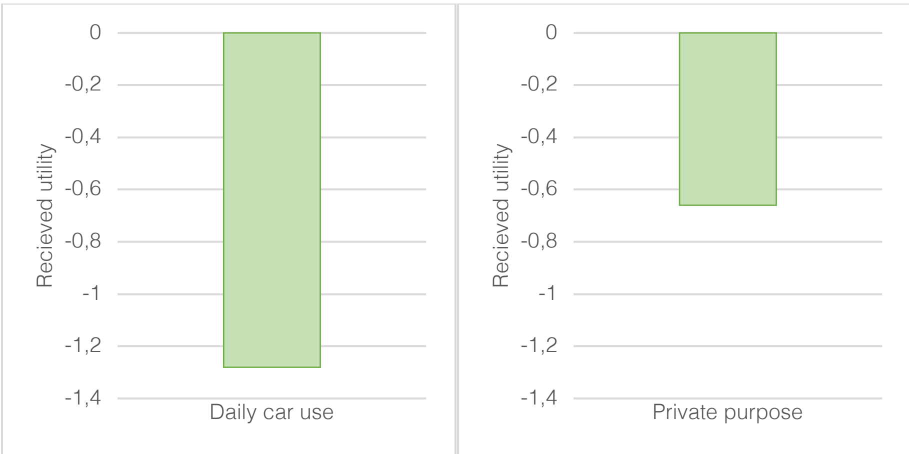


Figure I.15: Utility contribution of the level of frequency of car use (left figure)
Figure I.16: Utility contribution of the level of the purpose of car use (right figure)

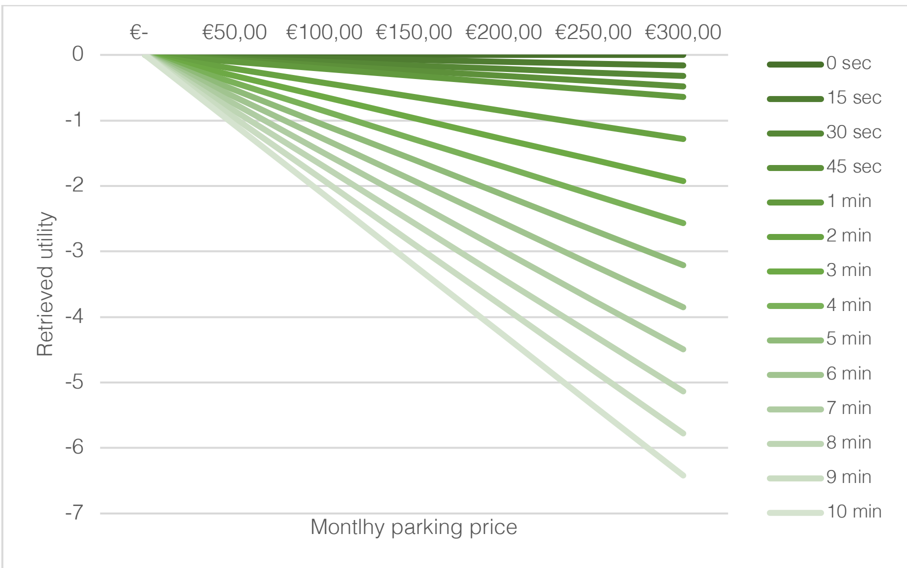


Figure I.17: Utility contribution of the interaction between current walking time to the car and monthly parking price of a car parking facility in a car restricted residential area

Lastly, the results of the ML model indicate that people that currently pay monthly for parking their car on average do not prefer to move to a car restricted residential area, whereas people that bought a car parking space do prefer to live in a car restricted residential area. The estimated parameter value for the interaction between the monthly price for parking a car in a car restricted area and currently paying for car parking is -0,0024. This indicates that on average people that currently pay for parking their car do not prefer to move to a car restricted residential area. An increase in the monthly price for car parking, therefore, decreases the utility received for living in a car restricted area (see Figure I.17). This was not expected, as people already paying monthly for car parking were considered to be more open for car parking costs in a car restricted area. On the other hand, people that bought a car parking space do associate a positive value to the monthly parking price in car restricted residential areas. It is even the case, as the parameter value of 0,00477 indicates, that with an increase in monthly costs for car parking people that currently bought a car parking space associate more value to living in a car restricted area. The effect on utility contribution is presented in Figure I.18. It may be that people that have bought a car parking space already park their car remote and therefore positively value living in a car restricted area.

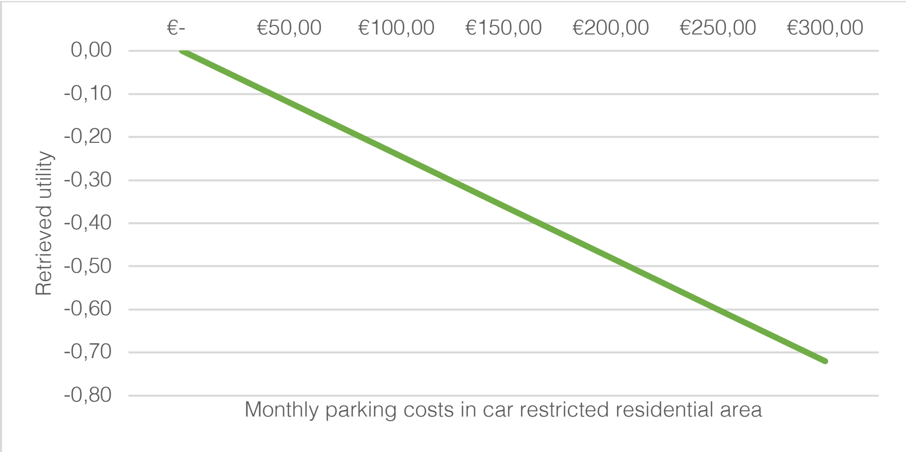


Figure I.18: Utility contribution of the interaction of parking price with current parking arrangement level: pays monthly for car parking

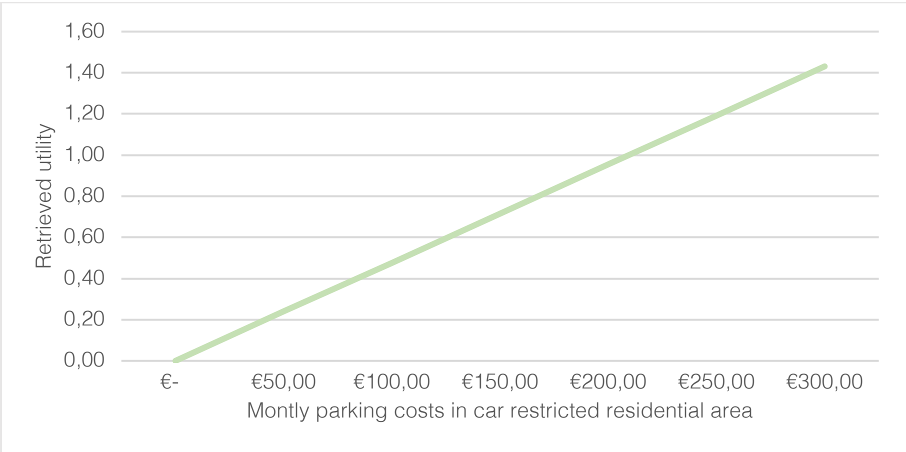


Figure I.19: Utility contribution of the interaction of parking price with current parking arrangement level: bought a car parking space

I.3.3 Current residential environment

Lastly, the effect of current residential environment on the preference for living in a car restricted residential area as assessed. Most of the variables which were significant in the MNL model turned out not to be not significant in the ML model. Only the house ownership variable turned out to have a significant effect on the willingness to move to a car restricted residential area after the ML model estimation. The estimated parameter value is -0,636. As rental was coded with one and buying with minus one this value indicates that people that currently bought a residence do value living in car restricted area positively, whereas people renting a house do negatively value living in a car restricted residential area.

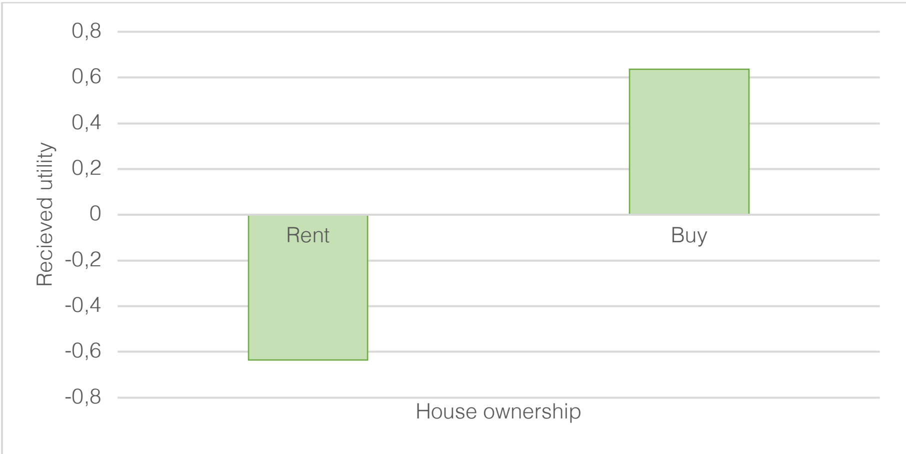


Figure I.20: Utility contribution of House ownership levels

I.3.4 The effect of attitudes

Additional to respondents' characteristics as socio-demographic variables, car use and current residential environment, the attitudes regarding car use and living environment that were significant in the MNL model are included in the ML model. Nevertheless, none of the attitudes seems to have a significant effect after estimating the ML model. This means that there was no specific influence of the *car-oriented attitude* and *the quality of the living environment attitude* on the perceived utility of car restricted residential areas. Also, the included interaction variables that measured the effect of these attitudes with perceiving the walking time to the car parking facility and money price of car parking were not significant. Moreover, the push and pull factors for car restricted residential areas did not have a significant effect on the utility for a car restricted residential area.

I.4 The relative importance of the variables

The estimation results presenting the coefficients of the variables that are estimated by the model cannot only be used to determine the utility contribution, however, can be used as an indication for the importance of these variables. Nevertheless, the coefficients' values cannot be used to assess which variables have the biggest contribution to the utility of a car restricted residential area, since every variable can obtain a different range of values. For this reason, for every significant variable, it was calculated what their relative influence is on the utility of a car restricted residential area. This was computed based on parameter values and the corresponding attribute value ranges. The relative importance of the variables is indicated in Table I.1.

Considering the relative importance of the attributes, the monthly parking costs do have the highest influence on moving to a car restricted residential area or not (33,3%). The walking time to the car parking facility has the second-highest influence on the decision to move to a car restricted residential area (26,0%). The facilities in the car restricted residential area offered do influence this decision as well. Only a supermarket has a relative importance of 13,2% and a simple range of facilities 11,2%. The liveliness on the streets, specifically hardly people on the streets has a relative importance of 8,6%. Lastly, the relative contribution of green facilities equals 7,7%.

With regard to the relative importance of all the significant variables including other respondent's characteristics as well, the influence of the household composition and time people currently walk to their car does seem to influence the choice to move to a car restricted residential area more. The interaction between the time that people currently walk to their cars and the monthly price of car parking in the car restricted residential area has the highest relative importance (31,6%). Subsequently, the interaction of walking time to the car parking and household size and composition have the second and third biggest relative influence (respectively 17,0% and 12,3%). Furthermore, current house ownership relatively affects the decision to move to a car restricted area for 6%. And the relative importance of the interaction between the levels of current parking paying arrangement and the parking costs in a car restricted residential area is 3,5% for currently paying monthly for parking costs and 7,0% for buying a parking space. Daily using a car relatively influences the decision to move to a car restricted residential area for 6,3%, whereas using a car for only private purposes relatively influences this decision for 3,2%. The total relative importance of the attributes equals only 12,7%, from which the monthly parking costs (4,2%) and the walking time to the car parking facilities (3,2%) relatively have the highest contribution of the attributes. Hardly people on the street (1,1%), only a supermarket (1,7%), a simple range of facilities (1,4%) and one big central park (1,0%) make up for the other 5,1% of the relative influence.

Table I.1: The relative importance of variables

	Coefficient value	Minimum value	Maximum value	Utility contribution range	The relative influence of the attributes	The relative influence of the variables
Attributes of the alternatives						
Walking time to the car parking facility	0,0787	0,5 min	9 min	0,669	26,0%	3,3%
Monthly parking costs	0,00285	€0	€300	0,855	33,3%	4,2%
Liveliness level in the car restricted residential environment						
Hardly people on the street (1)	-0,221	-1	1	0,221	8,6%	1,1%
Facilities in the car restricted residential environment						
Only a supermarket (1)	0,338		1	0,338	13,2%	1,7%
A simple range of facilities (2)	-0,288			0,288	11,2%	1,4%
Green facility level in the car restricted residential environment						
One big central park (2)	-0,199	0	1	0,199	7,7%	1,0%
Socio-demographic variables						
Household composition						
Interaction between time and household size	-0,0776	0	45	3,453		17,0%
Interaction between time and kids between 0–5 years	0,139	0	12	2,502		12,3%
Car use						
Frequency of car use						
Daily base (1)	-1,28	0	1	1,280		6,3%
Purpose of car use						
Private (1)	-0,66	0	1	0,660		3,2%
Current walking time to the car						
Interaction between Price and current walking time car	-0,00214	0	5000	6,420		31,6%
Current parking paying arrangement						
Interaction between Price and Pays monthly for car parking (1)	-0,0024	0	300	0,720		3,5%
Interaction between Price and Bought a car parking space (2)	0,00477	0	300	1,431		7,0%
Current residential environment						
House ownership	-0,636	-1	1	1,272		6,3%

I.5 Summated utility contributions of walking time to and monthly costs of car parking

The parameters walking time to the car parking facility and monthly car parking costs on first sight seem to be valued positively. However, the estimation results indicate that both variables interact with other variables. Thereby it is useful to determine the effects of these interactions to the overall valuation of the walking time to and monthly costs of car parking.

To be able to interpret the effects of household composition to the perceived walking time to the car parking facility, the average household distributions are substituted from the population. These allow to calculate the average utility contributions of the household composition. Table I.2 displays the utility contributions of the household size and household composition to the perceived walking time to the car parking facilities. Taken these contributions into account, the positive parameter for walking time to the car parking facility is levelled and on average seems to be perceived negatively (-0,076).

The same is performed for the monthly parking costs. The estimation results show that this variable is affected by people's current walking time to their car and their current car parking arrangements. The distributions of the current walking time and car parking arrangements are substituted from the sample and used to determine the utility contribution per variable level. The utility contributions of each level of current walking time to the car and current car parking arrangements are displayed in Table I.3. When accounting for people's current walking time to their car and people's current car parking arrangements, which are both perceived negatively, the positively parameter for monthly car parking costs is levelled and becomes negative (-0,000483).

Table I.2: Summated utility for a minute of walking time to the car parking facility

Variable	Distributions	Part-worth utility	Utility contribution
Walking time to the car parking facility			0,078
Average household size	2,15**	-0,078	-0,167
Households with 1 child in the age category 0-5	3,5%**	0,139	0,005
Households with 2 children in the age category 0-5	2,1%**	0,278	0,006
Households with 3 children in the age category 0-5	0,2%**	0,417	0,001
Summated utility for a minute of walking time to the car parking facility			**-0,076**
* sample derivative **population average			

Table I.3: Summated utility for a euro of monthly parking costs

Variable	Distributions	Part-worth utility	Utility contribution
Monthly parking costs			0,003
Current walking time to the car (minutes)			
0	26,9%*	0	0,000
1	38,5%*	-0,002	-0,001
2	15,2%*	-0,004	-0,001
3	11,3%*	-0,006	-0,001
4	1,9%*	-0,007	0,000
5	5,1%*	-0,011	-0,001
10	1,2%*	-0,214	0,000
Current parking arrangements			
Yes, monthly costs	43,2%*	-0,0024	-0,001
Yes, bought a parking place	18,2%*	0,0047	0,001
Summated parameter for monthly car parking costs			**-0,0005**
* sample derivative **population average			

J

Appendix: Model application

J.1 Determining the effect of design variables on the willingness to move

Next to the influence of household composition, people's current walking time to their car and their current car parking arrangements, car use and house ownership seem to influence the willingness to move to a car restricted residential areas. Similar to Section I.5 the average utility contributions of these variables is determined according to the car usage and house ownership levels of the sample and population. 41,2% of the sample indicated to use their car daily, furthermore 44,7% of the car owners expressed to use their car primary for private purposes. These distributions are used to determine the average utility contribution of these variables to the overall willingness to move to a car restricted residential area. Equally, the utility contribution of house ownership is determined according to the average distributions of people that rent or own a house in the population. Table J.1 displays the average utility contribution of these variables.

Table J.1: Average utility for car use and house ownership

Variable	Distributions	Part-worth utility	Utility contribution
Daily usage	41,2%*	-1,28	-0,527
Primarly private purpose usage	44,7%*	-0,66	-0,295
Residence renters	41,5%**	-0,636	-0,264
Residence purchasers	58,5%**	0,636	0,372
* sample derivative **population average			

The utilities of the variables are then used to determine the effect of design variables on the willingness to move to a car restricted residential area. This calculated by determining the elasticity. Elasticity is measure used to quantify to which extent the choice probabilities of alternatives change due to changes in the value of an attribute (Koppelman & Bhat, 2006. P48). The percentage change in the choice probability of an alternative (P_i) according to a change in the attribute level (X_{ik}) can be calculated using the parameter value of the according attribute (β_k) (see Equation J.1).

$$\eta_{x_{ik}}^{p_i} = \beta_k X_{ik}(1 - P_i) \tag{J.1}$$

The basic choice probability for preferring to move to a car restricted residential area is set as (P_i). The basic choice probability is determined with the alternative specific constant for moving to a car restricted residential area (-2,16). The base percentage for moving to a car restricted residential area without the influence of design variables is thereby equal to 10,3%. According to this base preference, the percentage changes in willingness to move to a car restricted residential areas as a result of changes to the design of the neighbourhood are calculated. The results are presented in Table J.2.

Table J.2: Effect on the base level of willingness to move to car restricted residential areas as a due to design variable level moderations

Design variable	*Design variable level*	*Parameter value*	*Effect on willingness to move*
Walking time to the car parking facility	*One minute*	-0,076	-6,9%
Type of car parking facility	*Private parking space in a parking garage*	-0,214	-19,2%
	Public parking garage	0,191	17,1%
	Public parking lot	0,023	2,1%
Monthly parking costs	*€25,-*	0,000	-1,1%
Type of building in the residential area	*Mainly* high-rise *building*	-0,017	-1,6%
	Mainly low-rise building	-0,223	-20,0%
	Mixed high and low-rise	0,240	21,5%
The liveliness level in the residential area	*Hardly people on the street*	-0,221	-19,8%
	Lively street scene with residents	0,030	2,7%
	Lively street scene with residents and trespassers	0,191	17,1%
Facilities in the residential area	*Only a supermarket*	0,338	30,3%
	A simple range of facilities	-0,288	-25,8%
	A broad range of facilities	-0,050	-4,5%
Green facility level in the residential area	*Small parks spread throughout the neighbourhood*	0,154	13,8%
	One big central park	-0,199	-17,8%
	Streets with wide grass strips and trees throughout the neighbourhood	0,045	4,0%

Additionally, the effect of car use and house ownership on the willingness to move to a car restricted residential area is determined. This is also calculated via direct elasticities as presented in Equation J.1. The results are presented in Table J.3.

Table J.3: Effect on the base level of willingness to move to car restricted residential areas as a due to car use variables and house ownership

Design variable	*Design variable level*	*Parameter value*	*Effect on willingness to move*
Car use	*Daily usage*	-0,527	-47,3%
	Primarly private purpose usage	-0,295	-26,5%
House ownership	*Residence renters*	-0,264	-23,7%
	Residence purchasers	0,372	33,4%

J.2 Willingness to move for multiple car restricted residential area designs

The parameter values are used to determine for several designs car owners' willingness to move to a car restricted residential area compared to a conventional residential area. Table J.4 to Table J.7 are indicating the percentages of car owners choosing to live in these types of areas according to several walking times to the car parking facility and monthly car parking costs.

Table J.4: Percentages of car owners willing to move to a spacious car restricted urban district according to the location and monthly costs of car parking

	0,5 min	3 min	6 min	9 min
€ -	4,3%	3,6%	2,9%	2,3%
€ 50,00	4,2%	3,5%	2,8%	2,2%
€ 100,00	4,1%	3,4%	2,7%	2,2%
€ 150,00	4,0%	3,3%	2,7%	2,1%
€ 200,00	3,9%	3,3%	2,6%	2,1%
€ 250,00	3,8%	3,2%	2,5%	2,0%
€ 300,00	3,7%	3,1%	2,5%	2,0%

Table J.5: Percentages of car owners willing to move to a spacious car restricted suburb according to the location and monthly costs of car parking

	0,5 min	3 min	6 min	9 min
€ -	5,0%	4,1%	3,3%	2,7%
€ 50,00	4,8%	4,0%	3,2%	2,6%
€ 100,00	4,7%	3,9%	3,2%	2,5%
€ 150,00	4,6%	3,9%	3,1%	2,5%
€ 200,00	4,5%	3,8%	3,0%	2,4%
€ 250,00	4,4%	3,7%	2,9%	2,4%
€ 300,00	4,3%	3,6%	2,9%	2,3%

Table J.6: Percentages of car owners willing to move to a compact car restricted urban district according to the location and monthly costs of car parking

	0,5 min	3 min	6 min	9 min
€ -	5,7%	4,8%	3,8%	3,1%
€ 50,00	5,6%	4,7%	3,8%	3,0%
€ 100,00	5,5%	4,6%	3,7%	2,9%
€ 150,00	5,4%	4,5%	3,6%	2,9%
€ 200,00	5,2%	4,4%	3,5%	2,8%
€ 250,00	5,1%	4,3%	3,4%	2,7%
€ 300,00	5,0%	4,2%	3,3%	2,7%

Table J.7: Percentages of car owners willing to move to a compact car restricted suburb according to the location and monthly costs of car parking

	0,5 min	3 min	6 min	9 min
€ -	7,0%	5,8%	4,7%	3,8%
€ 50,00	6,8%	5,7%	4,6%	3,7%
€ 100,00	6,7%	5,6%	4,5%	3,6%
€ 150,00	6,5%	5,5%	4,4%	3,5%
€ 200,00	6,4%	5,3%	4,3%	3,4%
€ 250,00	6,2%	5,2%	4,2%	3,4%
€ 300,00	6,1%	5,1%	4,1%	3,3%

J.3 Compensation of walking time with physical environmental characteristics

The ability of the characteristics of the physical environment of a car restricted residential area to compensate for longer walking times to the car parking facility is illustrated in Figure J.1 to Figure J.4. The figures display that for each characteristic, the increase in walking time almost exponentially decreases the willingness to move to a car restricted residential area. Longer walking times to the car parking facility may, thus, not be easily compensated with enhancements to the physical environment. The locations of parking facilities, therefore, should be considered carefully.

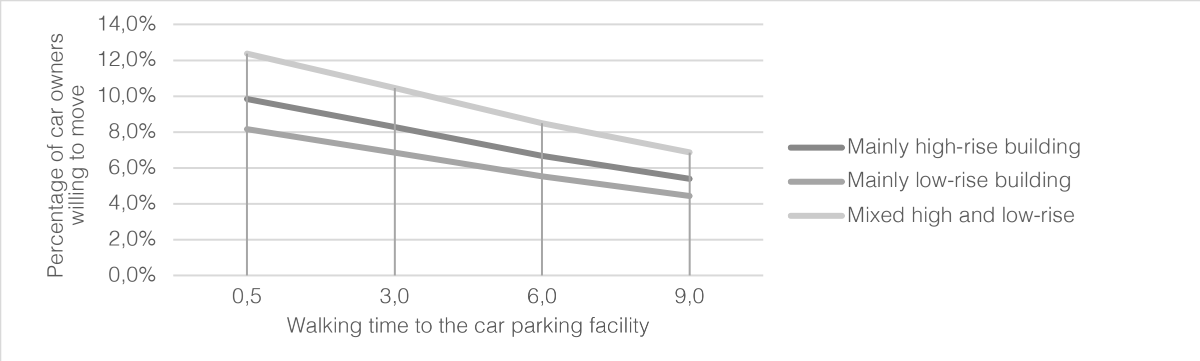


Figure J.1: The ability of building types to compensate for walking time to the car parking facilities

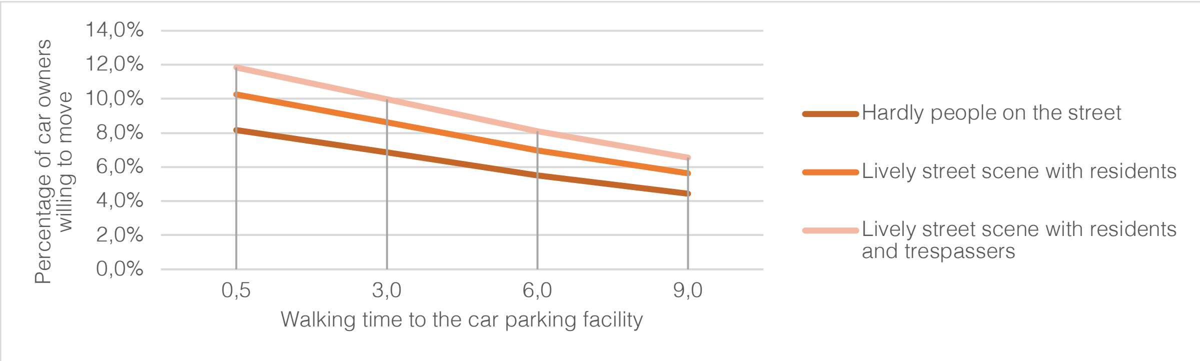


Figure J.2: The ability of the residential area's liveliness level to compensate for walking time to the car parking facility

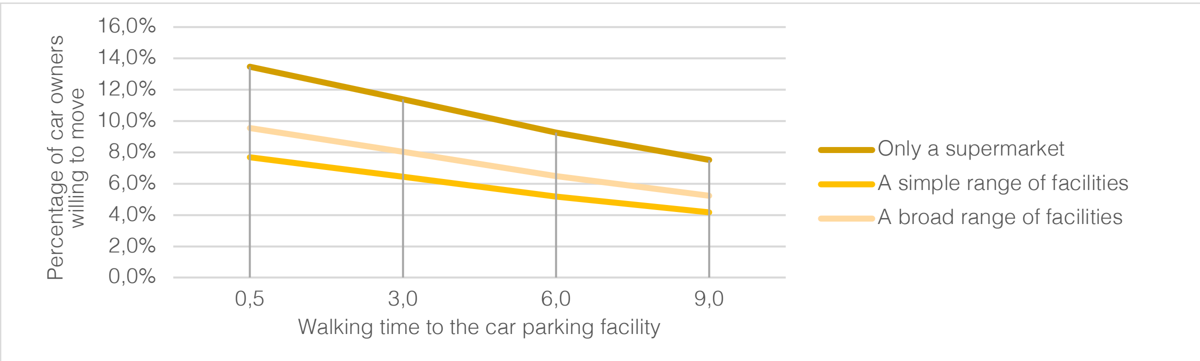


Figure J.3: The ability of facilities to compensate for walking time to the car parking facilities

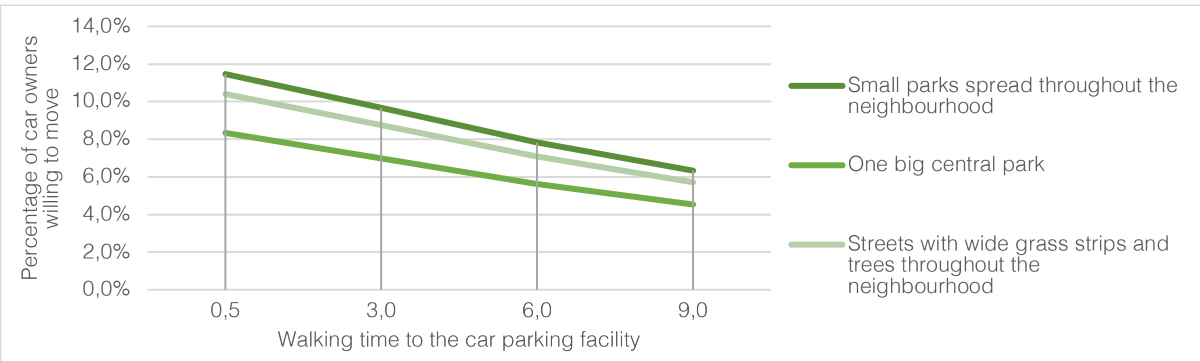


Figure J.4: The ability of green areas to compensate for walking time to the car parking facilities