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Transport inequality in the Netherlands

Exploring transport vulnerabilities and transport poverty risk

This research is performed at both the Technical University of Delft and the Ministry of Infrastructure and Water Management.

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By

L. Wisse

in partial fulfilment of the requirements for the degree of

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Preface

This study is the final product of my academic career constituted of the bachelor 'Technische Bestuurskunde' and the master 'Complex Systems Engineering and Management'. I started my bachelor in the year 2018 in which I immediately chose the transport and logistic track. During the next five years, my interest in transport and mobility has greatly increased. The internships at the Ministry of Infrastructure and Water Management with the team 'Innovation and Strategy for Mobility' and at the 'Netherlands Institute for Transport Policy Analysis' have been a great experience to end my master.

I want to thank my supervisors from the Delft University of Technology, Maarten Kroesen and Oscar Oviedo Trespalacios, who helped me throughout the thesis period. They provided essential assistance of the Latent Cluster Analysis approach and contributed critical and valuable feedback on my thesis process.

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In addition, I want to thank my supervisor at the Policy Analysis Institute, Lizet Krabbenborg, who has been a tremendous help on the theory of transport poverty. She has done her own research on the topic which lifted the quality of my study.

Laurens Wisse
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Abstract

Political and societal attention on transport inequality, transport vulnerabilities and transport poverty risk has been increasing the last five years. The Dutch government has committed multiple large sums of resources to abate the issue, 120 million euros to cancel the increase in price of train tickets, 300 million to cancel the increase in price and preserve the provision of the regional public transit and 6 million to start a pilot of 'innovative public transport' in the Zeeland region. A review of the literature on transport poverty risk reveals that past studies analyze the concept using a limited number of pre-selected variables. For example, car ownership and residence area. This carries the risk for misinterpretation as an accurate representation can only be achieved by considering all relevant variables. Such a comprehensive analysis could allow policymakers to formulate tailor-made policies according to the specific problems and needs of certain groups in society. This study aims to include the entire complexity of the concept of transport poverty risk in the analysis. Relevant factors include affordability, accessibility and mobility. Then there are individual differences, and for every individual changing over time, between needs of participating in society and social life. This study aims to incorporate this comprehensive definition in a Latent Class Analysis approach to construct groups of individuals based on the MPN and ODiN national datasets. The different groups of individuals can be then used to indicate the effect of policies on transport inequality. Results show three groups that are most transport 'fortunate', with high income, high car ownership, high accessibility and the potential to use different travel modes. Results also show one group with substantial transport vulnerabilities due to higher car dependency, lower car ownership and lower household income. A policy thought experiment is established through the application of mobility policy packages of three political parties. Car policies that reduce costs per driven kilometer such as reduction in excise tax will increase transport inequality due to the three groups that are the most transport 'fortunate', which also have the highest car use. This study provides the scientific community with a comprehensive definition and conceptual model of transport poverty risk and for policymakers contributes a comprehensive understanding of transport inequality in the Netherlands. Future research needs to focus on identifying specific minority groups that are not or less captured in the national datasets. Transport problems are experiences by an individual, while transport inequality is represented by the differences in the extent of transport problems between certain individuals or groups. In this case, certain groups in the Netherlands. This calls for the need to differentiate the government levels at which transport inequality and transport problems are addressed. While this study presents the transport inequality at the national level, municipalities will be able to identify specific individuals and neighborhoods who are more prone to transport problems.

Executive summary

Society exists from relationships between its members. Many relationships continue to require participants to physically meet, often involving so-called personal transportation. For a particular person, places that should be, and remain, within reasonable reach may – come to – vary. During a person's lifetime such places often include education, work, shops, the doctor's practice, a pharmacy, a police station, a hospital and, of course, residences of family and friends. Modes of transport that may, or may not, be available to a person include walking, public transport and/or the private use of a car or bicycle. The concept of transport poverty describes the phenomenon that a person is not able to reach essential locations. There are various reasons to explain this, such as large distances to these locations, not possessing adequate transportation or health limitations. The specific explanations are bound to vary between individuals. The consequences come down to the person risking the inability to participate in society, social isolation and a decline in overall well-being. In the Netherlands, attention of transport poverty has increased in the last five years. The Ministry of Infrastructure and Water Management has transformed transport poverty into the concepts of 'transport inequality' and 'accessibility for all' which are included in the 'Mobility Vision 2050'. Multiple studies from Dutch governmental organizations have demonstrated the existence of transport inequality between different societal groups. These studies highlight the significance of factors such as age, residence areas and car ownership. The Dutch government has already started tackling these challenges as committed 120 million euros to cancel the increase in price of train tickets and 300 million to cancel the increase in price of the regional public transit. In Zeeland, a region more prone to transport problems, the government has committed 6 million euros to start a pilot of 'innovative public transport', which aims to solve the low accessibility and reliability of public transport in the region. It is clear that there is a lot of political and societal attention surrounding the concepts of transport inequality and accessibility for all.

The scientific community has also adopted the concepts of transport poverty and transport inequality. It is first important to explain the difference of the two concepts. Transport poverty refers to the phenomenon that an individual is unable to access essential locations. Transport inequality refers to a broader, in this case national, representation of the differences in the levels of transport poverty. So, the differences of the levels of transport poverty between certain groups in the Netherlands. A wide range of studies conducted either quantitative or qualitative research to identify potential causes, the societal groups most at risk and to determine the definition. The literature recognizes the difficulty of measuring the exact percentage of members of society that is transport poor and refer to the concept as the risk of transport poverty. This study also acknowledges this and, for a combined approach, utilizes the concepts of transport poverty risk, transport vulnerabilities and transport inequality in its research. Past studies determine the effects at the level of a group of respondents or an area with the use of pre-selected variables and thereby exclude the individual aspect and a number of relevant factors. To design policies based on a limited number of pre-selected variables runs the risk of missing certain specific transport problems within these groups. For example, reducing the price of car fuel will have no effect on people who do not own a car or use public transport as their main means of transportation. This research aims to comprehensively investigate transport inequality and transport vulnerabilities in the Netherlands by including the entire complexity of transport poverty risk. This results in the following main research question:

What are the transport vulnerability groups associated with transport poverty risk in the Netherlands and how do future mobility policies affect transport inequality?

In answering the research question and fulfilling the research objectives, this research is structured in three phases. The first phase conducts a literature review to construct a comprehensive definition of

transport poverty risk and to design a conceptual model to define and visualize the entire complexity of the concept. The second phase utilizes two national mobility surveys, MPN and ODiN, and a Latent Class Analysis approach to identify, based on the definition and conceptual model, different groups in Dutch society. The LCA model creates these groups based on the patterns of the variables, subsequently determining of which group an individual is most likely a member. So, the groups are constructed based on the values of a wide range of variables which represent the situation in society, not based on a limited number of pre-selected variables. The respective advantages of the MPN and ODiN datasets are combined through the probability function. The MPN dataset is first used to construct the complex groups, with the resulting probability function then applied to integrate the ODiN dataset in order to assess whether the groups have experienced transport problems in the past. The third phase uses the latent groups as a thought experiment that allows policymakers to indicate how future policies effect transport inequality in the Netherlands.

The literature review reveals a comprehensive definition of the transport poverty risk which is based on three theoretical pillars. Firstly, the different factors that affect the amount of transport poverty risk can be categorized in affordability, accessibility and mobility. Low levels in any of these categorize can cause an individual to be transport vulnerable. However, this vulnerability can be compensated by high values on the others. Low levels on two or more categories can cause the individual real problems accessing essential locations. For example, an individual who does not own a car makes him or her vulnerable but this can be compensated by low distances to destinations and a high income. However, when this individual does not own a car and the distances to destinations are high, the risk of real transport problems is substantial. The second pillar of the definition is the consequence of the transport problems, which is the risk of the inability participate in society and social life resulting in a decline in overall well-being. The third pillar is the individual aspect of the concept transport poverty risk. The definition recognizes and emphasizes that every individual has different transportation needs and capabilities based on personal attributes. The definition is as follows:

"The process in which an individual is at risk of the inability of reaching desired activities and therefore participating in society and social life, due to poor affordability, accessibility or mobility, given the individuals' transport needs and capabilities".

Using the conceptual model of transport poverty risk, the LCA model is constructed with indicators of the MPN dataset. This dataset includes an adequate number of indicators which can indicate the affordability, accessibility and mobility levels of an individuals. The LCA model returns eleven latent groups in the Netherlands. The eleven groups are referred to as:

Cluster 1: High income suburban residents with high accessibility and high car use.
Cluster 2: High income urban residents with high accessibility and high car use.
Cluster 3: Older suburban residents with further away train station and hospital.
Cluster 4: Older urban car owners with high accessibility.
Cluster 5: High income moderate rural car users with low accessibility.
Cluster 6: Older suburban car owners with lower employment accessibility.
Cluster 7: Older moderate rural car users with high car accessibility.
Cluster 8: Urban residents with no car and high accessibility.
Cluster 9: Older rural car owners with lower PT accessibility and PT affordability.
Cluster 10: Rural car owners with extremely low accessibility.
Cluster 11: Young suburban bicycle and public transport users.

The cluster analysis reveals three groups of which the members are the most transport ‘fortunate’ in the Netherlands, groups one, two and five. These groups are characterized by high affordability due to high household income, high accessibility due to low distances to essential locations and high mobility due to high car ownership, car use and the option of other transport means. The group of which the members are most transport vulnerable is group three. This group includes individuals who are older, have higher health limitations and greater distances to entering and from exiting public transport. This results in a higher car dependency which is problematic regarding the lower car ownership and lower household income. The ODiN integration also reveals that these individuals have experienced past problems to access essential locations.

The eleven groups can be used by researchers and policymakers as a thought experiment to indicate how future policies influence transport inequality. In light of the ongoing government formation process, the mobility policy packages of three political parties are applied. Policies that reduce car costs per driven kilometer, have the most effect on the individuals who have the highest car use. This study reveals that these individuals are already the most transport ‘fortunate’ (groups one, two and five), which means that these policies will presumably increase transport inequality. Dynamic road pricing, which increases the costs for the highest car users and decrease the costs for the lowest car users, decrease transport vulnerability. Policies that decrease the costs of public transport will have a decreasing effect on transport inequality. It provides individuals that have financial difficulties with car ownership or have higher public transport costs, with a feasible alternative to the car and increases the ability to access certain essential locations.

This research contributes to the scientific literature with a comprehensive definition and conceptual model that aims to include the entire complexity of transport poverty, combining the advantages of the two national datasets with the LCA probability function. This study contributes to the policy field by providing policymakers with the current state of transport inequality in the Netherlands and a thought experiment to test the effect of future policies on the inequality. A limitation of this research is that several groups of individuals are missing from or unrepresented in the MPN and ODiN survey. These are non-Dutch citizens, one-person households and low-income individuals, which is an issue that should be addressed with priority as these individuals are often more prone to transport vulnerabilities and transport problems. Other groups such as low-literacy, digitally disadvantaged and mental disabled persons are unable to complete the surveys and therefore also excluded from the analysis while also being more prone to transport problems. In order to include these persons, it is recommended to engage different levels of government for addressing on one hand transport inequality and on the other specific transport problems. As this research provides an analysis on the transport inequality in the Netherlands based on the national representation of the MPN and ODiN datasets, specific individuals transport problems are better addressed at the municipality level. Municipalities are better capable to identify the individuals and neighborhoods that are more prone to transport poverty risk.

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1. Introduction

The first chapter presents the introduction of this research, starting with specifying the societal relevance of transport poverty risk along with the introduction of the theory and complexity. It continues with the defining the research problem, knowledge gap and research objectives. These aspects form the basis of the formulation of the main research question and the division into the sub research question. The sub research questions are further addressed to express the reasoning behind every research question. The introduction is concluded with the research flow diagram and the reading guide to clarify the structure of the research.

1.1 Societal relevance

In recent years, the concept of transport poverty has become recognized as a critical societal and therefore political issue (NRC, 2023a, 2023b; OVPro.nl, 2022). The problem has been given a number of different labels. 'Accessibility for all', 'transport inequality' and off course 'transport poverty' have all been used to describe the issue (CBS, 2018, 2019; KiM, 2018a; MinIenW, 2023a). Whatever label has been (dis)agreed upon, transport poverty has already received a great deal of government attention with policies addressing it as a problem in need of solution. Within the Ministry of Infrastructure and Water Management, 'accessibility for all' is a main subject with it being included as one of the components in the Mobility Vision 2050 of the Ministry of Infrastructure (MinIenW, 2023c). In November 2023, the second political conference was held with the sole purpose of addressing accessibility for all (MinIenW, 2023a). Many different governmental organizations in the Netherlands presented their view on transport poverty and how they are (planning to) aiding the individuals who are experiencing it. The minister and state secretary of the Ministry of Infrastructure and Management even pledged for 'accessibility' to be defined as a basic right (Van Vliet, 2023). The reasoning is that basic living needs such as healthcare, residence and food are human rights, however the ability to access the places at which these needs are met, is not. While its future relevance has been emphasized in the Mobility Vision 2050, 'accessibility for all' is the topic of a number of current policies implemented by the Dutch government. In the national budget announcement in September, the Dutch government committed 120 million euros to cancel the increase in price of train tickets and 300 million to cancel the increase in price of the regional public transit (RTL, 2023). This was agreed upon after a motion by the collaboration of two political parties, the Groenlinks and the PVDA (AD, 2023). The Dutch Government also launched a pilot for 'innovative public transport' the state of Zeeland. Zeeland is a rural region with low public transport accessibility, which calls for the need of flexible public transport. The government will invest six million euros in the pilot (Provincie Zeeland, 2023). It is apparent that there is substantial (political) attention surrounding transport poverty and accessibility equality (NRC, 2022; OTAR, 2023).

The extent of the issue remains challenging to quantify. This is partly due to the complexity of the concept and the difficulty to identify the specific disadvantaged societal groups. There have been a number of studies and reports that aim to identify the percentage of citizens with transport 'problems. The 'Laboratorium Verantwoorde Mobiliteit' has written a report which estimates that 11% of the households or approximately 1,3 to 1,4 million individuals experience transport problems. This is done using a combination of car ownership and financial capacity estimations within the population (Jeekel & Martens, 2017; Laboratorium Verantwoorde Mobiliteit, 2023). Bastiaansen and Breedijk (2022) conducted a study to identify the accessibility of essential destinations such as schools, supermarkets and hospital of different residential areas, age groups and times of day. They concluded that 12% of the older generation cannot access a hospital within 45 minutes using public transport and that 10% of the youth in the Netherlands cannot access a VBO/VMBO school using public transport (for HAVO/VWO 17%). Lastly. Pot and the University of Groningen conducted a study to identify the perceived

accessibility satisfaction in both urban and rural areas. They concluded that 12% of the individuals in rural areas experience transport problems versus 8% in urban areas (Pot et al., 2023). It is clear that these studies and reports use different perspectives of transport problems, needs and indicators to assess the problem. The different studies form a clear layer of evidence that there are in fact individuals in the Netherlands that experience transport problems.

Transport poverty and social exclusion are complex concepts and are very difficult to measure, as is demonstrated by the different studies mentioned above. The different aspects of transport poverty are represented by many factors. Such as car ownership, distances to the destinations and train ticket prices. Additionally, everyone has a different need for mobility and accessibility to the essential activities. Meaning person A wants to take the bus to school every day even if it takes a little longer and person B works from home four days a week. So, to include only a limited number of factors, is ignoring the other aspects, creating a misrepresentation of the problem. Not every individual who does not own a car, is transport poor and not everyone who cannot access a train station is transport poor. If the objective is to specify a definitive number or percentage of individuals who are transport poor, there is a need for a legal minimum of transport accessibility, mobility and affordability. Meaning answering the many questions of: “how many supermarkets should someone be able to access within a number of minute or kilometers?”, “should everyone be able to have access to a car?” and “what is the maximum price for a bus or train ticket?”. Clearly, the problem of quantifying the amount of transport poverty in the Netherlands is too complex. That being said, the different studies prove that there is at least transport inequality present in the Netherlands. There are a certain group of people who experience more barriers to access their activities and participate in society and social life. The complexity of the problem reveals that there is not one general solution in the shape of a single policy intervention, but a need for tailor made policies according to the needs of these different groups of individuals. It is also valuable to have the ability to test future policy intervention whether they influence the transport disparities in the Netherlands. In order to clarify the problem, this research adopts the formulation of ‘transport problems’, ‘risk of transport poverty’, ‘transport inequality’ and ‘transport vulnerability’, which also has been used in the studies and reports of Laboratorium Verantwoorde Mobiliteit (2023), Bastiaanssen & Breedijk (2022), Pot (2023) and KiM (2023).

1.2 Research problem and research questions

1.2.1 Knowledge gap and research objectives

Previous quantitative studies in the scientific community have used a wide variety of factors and methods to measure transport poverty risk and its causes. They have captured a number of relevant relationships between these factors and transport poverty risk. Such as the negative effect of income (Allen & Farber, 2019, 2020b; Alonso-Epelde et al., 2023; Lowans et al., 2023; Lunke, 2022; Pérez-Peña et al., 2021; Sterzer, 2017; van Dülmen et al., 2022) and the negative impact of rural areas (Allen & Farber, 2020b; Kelly et al., 2023; Lunke, 2022; van Dülmen et al., 2022). However, these quantitative studies do not include the notion that transport poverty risk is an individual concept and instead assess the effects based on the respondents as one group or based on certain regions. The individuality of transport can be supported by the differences of personal attributes of individuals. These differences create different destinations the individuals need to access, different abilities to access and use certain modalities and different level effort the individuals need to make to make the trips. A simple example is the difference between an individual who is retired and an individual who still works five times a week. If these individuals both live in an area which has lower employment accessibility, only the individual who works five times a week experiences larger barriers to access his or her employment. Analysis using geographical data does improve this by identifying specific effects related to different regions (Allen & Farber, 2020b; Jiang et al., 2020; Kelly et al., 2023; Lucas, 2018; Lunke, 2022; van Dülmen et al., 2022). However, within a certain region there is also a possibility of groups of individuals with variating transport vulnerabilities.

There is a gap in the literature where the complexity due to the individualism and the combination of the many indicators, is missing. Individuals with different transport needs and capabilities are placed in the same group for analysis. Even within the same household, the transport needs and capabilities can differ. Another example is a woman who works five days a week also has very different transport needs than the husband who chooses not to work and take care of the children. There is a possibility that individuals can experience different versions of transport problems, related to their transport needs and capabilities. For example, one person can have transport problems due to accessibility issues and the other due to affordability issues. This means that these persons can be sensitive to different indicators within their transport problems, such as train ticket price or distance to essential activities. Ignoring these differences between individuals can result in neglecting groups of individuals that differ from the ‘average effects’ found by the existing literature. It creates the risk that potential policy interventions will not be effective for people that differ from these average effects. For example, a decrease in public transit prices can be pointless for people who (have to) take the car to work. This is where the difference between transport poverty risk (or transport problems) is important. Transport poverty risk refers to the individual’s ability to access destinations. This ability is formed by the factorial complexity and the individuals needs and capabilities. Transport inequality is, in this case, the national representation of the differences between the levels of transport poverty risk of certain groups. Past studies have resulted in different representations of transport inequality of a country, however, did not include the complexity of transport poverty risk. So, it is important to first account for the complexity and then use the differences between the levels of transport poverty risk of certain groups to indicate the extent of transport inequality.

In addition to the lack of individuals’ transport needs and capabilities, the literature analysis a group or region based on a set of pre-selected variables. These variables do not represent the entire complexity of transport poverty risk as not all relevant variables are included. Pre-selecting a limited number of variables carries the risk that the results do not represent the actual societal situation. This can cause policymakers to design policies that are not effective for certain groups of individuals as their specific

problem is not considered in the analysis. So, there is a need for an analysis which includes the entire complexity of the concept and captures post-hoc groups based on individual values for a wide range of variables. This way, policymakers can design effective policies for specific groups of individuals based on a more complete representation of transport inequality and transport poverty risk.

Fransen and Vertriest (2021) performed a study in Belgium which analyzed individuals who indicated to not travel two days per week and defined these individuals as less mobile. The study correctly analyzes transport poverty risk on individual level, which allows the identification of who these individuals really are and where they live. The assumption used to define a person as less mobile, is however very arbitrary. The individual's transport needs are not taken into account along with the reasons why someone is not travelling two days a week. The example of a person who is retired is still valid here, meaning that this person does not need and/or want to travel two days per week. This does not mean that this person is less mobile or is at risk of transport poverty.

To summarize, the review of the literature reveals a need for an analysis that combines the individualism and the factorial complexity of transport poverty risk and transport inequality, to enable policymakers to better consider the effects of future policies on relevant groups in the Netherlands. This gap in the literature results in four main objectives of this research. First, this study aims to construct a conceptual model which explains the entire complexity of transport poverty risk, including all relevant sub concepts, factors and personal attributes. Second, this study aims to use a Latent Cluster Analysis to construct post-hoc groups based on the wide range of factors. Third, this study aims to use the groups to present transport inequality in the Netherlands and identify potential transport vulnerabilities. Fourth, to create a thought experiment for policymakers to test their future policies of effects on the inequality.

1.2.2 Research questions

The societal relevance, knowledge gap in the literature and the research objectives can be translated into the main research question. The main research question is then divided into sub questions to create the structure in the research. The sub questions represent the path to eventually answering the main research question. The main research question is:

What are the transport vulnerability groups associated with transport poverty risk in the Netherlands and how do future mobility policies affect transport inequality?

The main research question consists of two parts. The first part is identifying what the different groups of individuals are in the Netherlands associated with transport poverty risk. Associated with transport poverty risk means that the groups are constructed using factors that can indicate transport problems. The groups should represent the Dutch population and therefore be able to indicate actual vulnerabilities. The second part of the main research question is aimed to utilize the groups for identifying effects of potential policies regarding mobility. For example, the increase in fuel tax or the decrease of train ticket prices. The aim is to determine to what extent these policies influence the transport disparities identified between the groups. The intention of this research is thus to reason along the lines of transport vulnerabilities, transport problems and transport inequality.

The sub questions are as follows:

Table 1: research sub questions.

SQ1 What is the conceptual model of transport poverty risk when accounting for the individualism and factorial complexity?
SQ2 Which indicators of transport poverty risk are available to use in the Netherlands?
SQ3 Which groups in the Netherlands experience transport vulnerabilities?
SQ4 To what extent have these groups experienced transport problems in the past?
SQ5 Based on the groups, what are the transport vulnerabilities according to policymakers?
SQ6 What is the effect of future mobility policies on the potential transport disparities between the groups?

SQ1 What is the conceptual model of transport poverty risk when accounting for the individualism and factorial complexity?

The first sub question related to the (scientific) literature of transport poverty. It is clear that transport poverty risk is a very complex concept with many different factors and sub concepts regarding the consequences. This research aims to combine the different factorial categories, consequences into a comprehensive definition and visualization of the conceptual model of transport poverty risk. This definition and conceptualization will also introduce the individual's complexity into the concept. The definition is necessary to conduct further statistical research.

SQ2 Which indicators of transport poverty risk are available to use in the Netherlands?

The second sub question of this research converts the theoretical analysis which includes the comprehensive definition and the conceptual model with the different factors used in the literature, into a conceptualization of the statistical model. In other words, to answer this question it is necessary to compare the available surveys and the included factors to the conceptual model of transport poverty risk in order to conclude whether a set of factors in the Netherlands is complete enough to construct transport vulnerability groups. It is also important to identify what factors are missing in the Netherland and what consequences that could have on the research.

SQ3 Which groups in the Netherlands experience transport vulnerabilities?

The third sub question includes the presentation of the results from the grouping of the individuals and the identification of the potential transport vulnerabilities and transport disparities. The results will be presented with visualizations of the groups with the associating particulars of the factors. The values of the factors will be compared to the mean of the values of all groups, this means that this research will reason with relative values and differences. This allows this research to not only identify transport vulnerabilities but also determine transport disparities between the groups.

SQ4 To what extent have these groups experienced transport problems in the past?

The fourth sub question is partly associated with the third sub question. Answering both sub questions is an important part in allowing this research to draw more effective conclusion. The third sub question mainly allows for assessing whether the individual is prone to future transport vulnerabilities and transport problems. However, even after answering the third question it is not possible not reason whether a group of individuals has in fact experiences transport problems. The fourth sub question will directly fill this gap in the reasoning. This question can be answered using one of the national surveys which analysis travel behavior. The survey should include a direct question whether the individual has experienced problems accessing certain essential locations.

SQ5 Based on the groups, what are the transport vulnerabilities according to policymakers?

The fifth sub question of this research is the first step of translating the results found by the data and the statistical method, into findings in the Dutch population. This step will utilize policymakers which are engaged in the field of transport inequality to validate the findings of the statistical model. The policymaker will be asked to combine the identified groups with her or his own experiences in their field of expertise to potentially identify vulnerabilities. Transport vulnerabilities are a real-world phenomenon, and it is therefore imperative to validate the groups constructed by a statistical model.

SQ6 What is the effect of future mobility policies on the potential transport disparities between the groups?

The sixth and last sub question represents the usefulness of this research for policymakers. This question will establish the groups as a thought experiment for indicating the effects of future policies on the transport disparities between the groups. General policies which are equal for all individuals in the Netherlands bear the risk to be effective for only a specific group of individuals and therefore influence the transport disparities. The groups will be constructed based on a correct representation of the population. It is important to note that the small, disadvantaged groups such as non-Dutch speakers or digital incapable are often not identified by national surveys. That being said, the groups represent the vast majority of the Netherlands are therefore appropriate to utilize for the assessment of the effects of policies on society.

1.2.3 Methodology introduction

The first two sub questions will be answered using desk research and a literature review. This means identifying relevant governmental reports, scientific literature and suitable surveys in the Netherlands. \ To allow theoretical comparison to the Netherlands, these scientific papers have to be applicable to the Dutch society. This research will utilize two national surveys: 'Mobiliteitspanel Nederland' and 'Onderweg in Nederland'. These surveys are performed at national level in the Netherlands so that the sample is comparable to the population.

The third and fourth research question requires a quantitative methodology in order to identify the answers (Goertzen, 2017; Sukamolson, 2007; Watson, 2015). The third question calls for a statistical method that groups individuals according to their scores and values on the indicators and personal attributes. In other words, the goal is to identify and construct different groups based on the transport poverty risk indicators and socio-demographic variables. This research will use the Latent Class Clustering method because of some essential advantaged it holds over traditional approaches. Firstly, LCA is the more flexible approach as a variety of distributional forms can be used for the variables within groups. Secondly, there is no decision required about the scaling of the variables, it does not matter if the variables are normalized. Thirdly, the LCA approach can deal with variables of different measurement types, so it allows nominal variables to be included (Magidson, 2002). Lastly, the method allows for statistical criteria to identify the optimal number of groups. Another advantage of LCA is used to answer the fourth research question. The LCA model establishes groups based on the individuals' values on the indicators, then combines the personal attributes to explain what kind of individuals are part of each group. It creates a probability function that calculates the probability of an individual to be part of a group given his or her personal attributes. This probability function can be used to combine one dataset with another, given that the personal attributes are included in both surveys. This will allow the combining of the advantages of different surveys.

The fifth and sixth research questions will be answered in collaboration with policymakers. To enable this collaboration, this research will conduct a consultation with policymakers. The structure of the consultation will be presented in the methodology chapter. The policymaker will provide their expertise on the potential transport vulnerabilities and on the effects of current and potential future policy developments.

1.3 Reading guide

In the research flow diagram, the research questions are paired with the associating phases in which they are answered. The methodologies and programs are specified below the questions. The output after every step is also presented.

The first chapter forms a literature review of past studies on transport poverty risk. The first chapter concludes with a comprehensive definition and a conceptual model. The second chapter investigates which factor of transport poverty risk are available in the national datasets. The conceptual model is used to identify which factors are used by past studies. The second chapter also presents which factors are not available in the datasets. In the third and fourth chapter the general approach of this research is outlined and a statistical method is used to construct the transport poverty groups. The fourth chapter presents the results from the cluster analysis and reflects on the potential transport vulnerabilities of the groups. The fifth chapter presents the policy analysis in which first, policymakers are asked to provide feedback on the results and second the groups are used to test future mobility policies. In the last chapter, the research questions are answered, the findings are compared with past studies and the contributions, limitations and recommendations are presented.

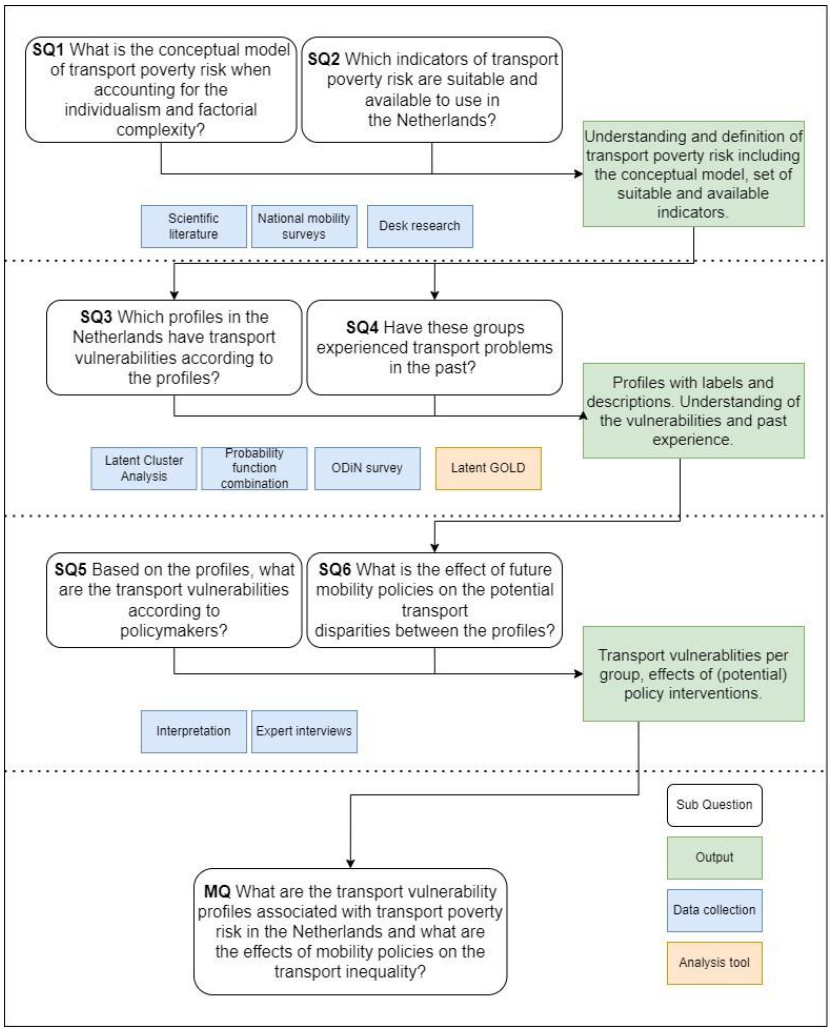

Figure 1: research flow diagram.

2. Theoretical analysis

The second chapter of this research present the theoretical review and theoretical analysis of transport poverty risk. The objective of this research is to formulate a comprehensive definition of transport poverty risk according to the scientific literature and to establish a conceptual model which visualizes this definition and relevant factors. In order to complete this objective, this chapter defines the three pillars which formulate the definition. To establish the conceptual model, the different factors used in the literature are identified and the main effects and findings on these factors are elaborated. This chapter concludes which the conceptual model of transport poverty risk.

2.1 Towards a comprehensive definition

2.1.1 Affordability, accessibility, mobility.

The concept of transport poverty has been a topic of research for both the international scientific community and organizations of the Dutch government. The literature has aimed to capture the definition, as well as establish criteria and metrics to measure the extent of transport poverty risk (Lucas et al., 2016; Verhorst et al., 2023). The European Union and the Dutch government captured the literature in their respective literature reviews and qualitative studies (KiM, 2018a; MeJía Dorantes & Murauskaite-Bull, 2022). The definition of transport poverty which is used by the vast majority of the papers, is provided by Lucas et al. (2016). This definition is the theoretical starting point of most of the qualitative and quantitative studies (Allen & Farber, 2019; Alonso-Epelde et al., 2023; Awaworyi Churchill, 2020; Awaworyi Churchill et al., 2023; Awaworyi Churchill & Smyth, 2019; Janson-Goossens, 2023; Kelly et al., 2023; Lowans et al., 2023; Lunke, 2022; Pérez-Peña et al., 2021; Shi et al., 2022; Van Der Bijl, 2020; Verhorst et al., 2023; Voorhorst, 2023). It states that transport poverty is a concept with four underlying notions: mobility poverty, accessibility poverty, transport affordability and exposure to transport externalities. Firstly, mobility poverty is defined as the systemic lack of transport that generates difficulties in moving. Secondly, accessibility poverty is defined as the difficulty of reaching key activities, such as education, healthcare services and employment. Thirdly, transport affordability is defined as the lack of individual or household resources to afford transportation options. Lastly, the exposure to transport externalities is defined as the outcomes of exposure to the negative effects of the transport system, such as road accidents and traffic pollution. In the literature, the exposure of transport externalities is often neglected as it has a more complex influence on the transport behavior of individuals and is therefore more difficult to measure and include in a quantitative study. The fact that the vast majority of the literature acquired by this research, utilize (a part of) the same definition of transport poverty, shows that the theoretical definition is adequately developed. The three aspects of affordability, accessibility and mobility will be further elaborated in section ‘Metrics and personal attributes in the literature’.

The quantitative studies use more specific measurements and criteria to assess one or more of these aspects. For example, the use of income and transport expenditure to determine whether an individual devotes more than 10% of its disposable income on transport (Alonso-Epelde et al., 2023). This shows that the aspects provided by Lucas leave room for interpretation. However, that does add to the complexity of measuring the exact number or percentage of individuals who may experience transport poverty. This then again raises the question at the start: "When exactly is someone transport poor?". The 10% threshold of transport expenses of the disposable income may seem like a valid criterion. However, if the paper would zoom in on other individual's notions of transport needs and capabilities, they would conclude that this threshold is not true for everyone. If for example, an individual has a high income and travels first class every day and therefore, spends more on transport, it does not mean that individual is transport poor. It is also noteworthy that Lucas labels every notion with 'poverty'. When doing so, it implies that every notion can directly cause transport poverty by itself. However, the levels of the other notions can possibly mitigate the 'poverty'. For example, someone living in the city is not automatically transport poor if that person does not have a car, because of the low distances to activities. Lucas does visualize this with transport affordability as affordability is not displayed as one sole aspect but is always in combination with another. The visualization is presented in figure 2.

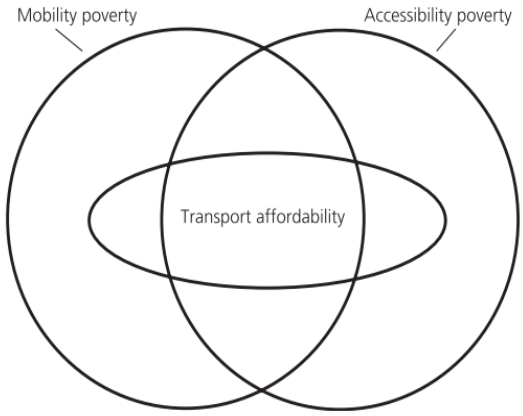

Figure 2: transport poverty model Lucas et al. (2016).

Lucas et al. (2016) also provides five general criteria which determine if an individual is transport poor. These criteria give an interesting overview of what a comprehensive definition of transport poverty would be.

1) 'There is no transport option available given the physical condition and capabilities of the individual'. This criterion directly adds the personal capabilities and needs into the definition, which influence the levels of mobility, accessibility and affordability necessary at which the individuals can access activities.

2) 'the individual cannot reach the activities they need to maintain a reasonable quality of life'. The second criterion clarifies the consequences of transport poverty. Inadequate levels of the three notions given the personal capabilities and attributes, can cause inaccessibility of essential destinations. This in turn can cause social exclusion and therefore affect quality of life and well-being.

3) 'the weekly amount spent on transport leaves the household with an income below the official poverty line' and

4) 'the individual is forced to spend an excessive amount on time travelling to reach the desired destinations. The third and fourth criteria are linked with the affordability notion. Affordability is however never the only cause, as the individual has to spend more because of low mobility or low accessibility levels. This remains unclear when only assessing the criteria.

5) 'the travel conditions are dangerous, unsafe of unhealthy'. The last criterion is linked with transport safety. This aspect and criterion are often excluded by other scientific papers. Transport safety is a multidimensional concept with both objective and subjective components. It is to a lesser extent directly related to the transport opportunities than the other three aspects, especially in a developed country like the Netherlands. Safety is also often not incorporated into national mobility surveys. So, because of the complexity, unavailability of factors and lesser relevance, will this research also exclude it after this point.

Lucas states that an individual can be labelled as transport poor if one of the criteria is true. When investigating the criteria, they are indeed general outcomes or causes of transport poverty. However, the criteria leave room for interpretation and do not give a clear roadmap for quantifying transport poverty. It is therefore important to elaborate on transport vulnerabilities, transport problems, transport poverty risk or transport inequity instead of transport poverty. Lucas provides a good starting point for a comprehensive definition of transport poverty risk. She does leave a lot of room for interpretation and falsely concludes that the aspects of mobility and accessibility can solely be the cause. This creates a gap of complexity in the definition of Lucas where activities, social exclusion and personal capabilities and needs are missing.

2.1.2 Activities and social exclusion

A substantial part of the literate is concerned with the concept 'transport related social exclusion', which is directly linked with transport poverty. Social exclusion is defined by the literature as "for reasons beyond his or her control he or she cannot participate in the normal activities of citizens in that society" (Jaroš, 2017; Kamruzzaman et al., 2016; Lucas, 2019; Luz & Portugal, 2022; Virág et al., 2022; Xia et al., 2016). A key word in this definition is 'activities'. The individuals are not able to reach the activities such as school, doctor or family which can result in social exclusion. This research defines the 'reasons' as the three aspects of Lucas et al. (2016). The purpose of transportation is to access these activities, and affordability, accessibility and mobility are the factors which determine the ease of difficulty of reaching the activities. Social exclusion can thus be the consequence of transport vulnerabilities and problems (Jaroš, 2017; Kamruzzaman et al., 2016; Lucas, 2019; Luz & Portugal, 2022; Xia et al., 2016; Yigitcanlar et al., 2019).

The literature identifies several properties of a transport system which could influence transport related social exclusion. Church et al. (2000) specify that social exclusion can results from large travel distances to essential destinations such as schools and hospitals, from high costs for example public transport tickets or car purchase, or from 'time poverty' due to other responsibilities such as employment and childcare. They further elaborate that physical hindrance due to disability, resident area, spatial exclusion and safety concerns are also important factors in social exclusion. Van den Broeck & Van Os (2015) adds that a limited network for alternative travel options, including travelling together, and personal abilities to navigate in the digital domain can also contribute to the risk of social exclusion due to the transport system. It is clear that the properties provided by these two papers, fall into the three aspects of transport vulnerability.

2.1.3 Personal transport needs and capabilities

This research has now identified the different aspect or instruments of transport vulnerability and identified the purpose of transportation and therefore the consequence of potential transport problems. However, there is still a part missing to complete the comprehensive definition, the individualism. The individual transport needs and capabilities are imperative in assessing whether an individual is able to access their desired destinations. If or what for activity the individual has to reach is depends on personal attributes and therefore differs for every person. For example, an unemployed husband who takes care of the children has very different transport needs than the wife who works five days a week. This is where the hinderance of mental or physical disabilities become significant. It is therefore apparent to include this notion of individualism in the analysis of transport vulnerabilities and transport poverty risk.

A different perspective on transport poverty risk which includes the individual perspective is the capability approach and the concept of 'motility'. The capability approach uses the concept 'motility' to determine the potential for mobility of an individual (KiM, 2018a; Van Uffelen & Lamker, 2023). The rationale is that only assessing mobility as movements in place and time, ignores the social phenomena

that surround that movement. Kaufmann et al. (2004) introduced the concept and divided motility into three relating aspects: access, competences and appropriation. Access refers to what an individual 'has' that could allow that person to travel, such as a car but also financial capacity. Competences refers the what the person 'can do', for example walking, driving a car or knowing how to use the public transport system. Lastly, appropriation refers to actual trip given what the individual has and can do, for example car use or public transport use. The access to mobility and the competences of an individual can be converted into motility. Whether the individual uses this potential for mobility and this the amount of appropriation, depends on the individual's transport needs. The question is whether the motility correspond with the individual needs. The appropriation of the motility is conditional to the individual's needs, values and habits. This means that two individuals could have the same amount of motility but different appropriations due to different needs and lifestyles (Kaufmann et al., 2004).

It is clear that this approach has many similarities with Lucas et al. (2016). The access and competences can be viewed as a detailed version of the 'mobility' notion of Lucas, which includes the property and the use of modalities. The capability approach often does not include the accessibility or the complete affordability notion, such as distances or specifically public transport costs. These notions are important in assessing whether an individual is transport vulnerable which means that the capability approach does not always provide a complete concept. The 'competences' notion does include factors which the concept of Lucas has missed. Firstly, the accessibility of public transport or taxis may not directly lead to the ability to use the modality. It is also important that the individual is aware of and is able to use the physical and especially the digital systems and networks in order to utilize it. Secondly, a car or bicycle have the possibility to break down after which the individual is often responsible to have it repaired or repair it themselves. However, not everyone has the financial capacity to have it repaired by someone else. It therefore also interesting to include someone ability to repair their modalities in their transport vulnerability analysis to assess the robustness of their mobility. The capability approach adds a valuable perspective on the individualism of the risk of transport poverty and shows that transport poverty is a very complex concept. The comprehensive definition should also include this perspective that the individual's needs, values and habits and thus personal attributes are apparent in translating the potential for movement to actual movement. This is important in assessing the ability of an individual to access the desired destinations or whether the individual in vulnerable to transport problems of transport poverty risk.

2.1.4 Comprehensive definition

There are three important relating components in a definition of transport poverty risk. Firstly, the three notions or resources which allow or disallow the individual to travel from A to B. Affordability, accessibility and mobility are also interrelated, with only a combination can cause transport problems. Unlike Lucas et al. (2016), this research will not refer to the three aspects in combination with 'poverty'. The reason is that one aspect can mitigate the poor value of another. For example, high accessibility with low distances can mitigate the negative effect of not owning a car and thus have lower mobility, or that high affordability can mitigate the negative effect of high travel distances and thus low accessibility. An individual who has a poor value in an aspect, is considered to be vulnerable in that aspect. However, due to the possible mitigating effect of the other aspects, it is not sufficient to label that individual as having higher risk of transport problems or transport poverty. Transport vulnerability is therefore referred to as the possibility of future risk of transport problems, and transport problems are the situation in which the individual cannot reach his er her desired locations. Secondly, the purpose of travelling is to reach a desired activity. This includes schools, general practitioner, family, sport and the hospital. These activities are part of society and construct the social aspects of life. Therefore, the inability of reaching these activities can cause social exclusion and a decline in quality of life and well-being. Thirdly, the individual needs and capabilities are an important part in the interpretation of transport vulnerabilities and problems. Personal attributes such as gender, age, employment status and household size determine the kind of activities, how often and what location the individual wants to reach.

It is important to take all three components into account when investigating the transport vulnerabilities of individuals. This research labels an individual as potential vulnerable if that person has poor values on at least two of the three notions of Lucas. Not doing so will result in misrepresentation of the problem. Further analysis of the personal needs and capabilities can then allow for the conclusion whether the individual is in fact transport vulnerable. Ultimately, this research provides a comprehensive definition of transport poverty risk:

"The process in which an individual is at risk of the inability of reaching desired activities and therefore participating in society and social life, due to poor affordability, accessibility or mobility, given the individuals' transport needs and capabilities".

2.2 Metrics and personal attributes in the literature

There are a number of scientific papers that aim to quantify transport poverty risk and identify the effects of various factors. These papers use a variety of indicators and personal attributes for its analysis. The indicators can be put under the categories created by Lucas et al. (2016): transport affordability, transport mobility and transport accessibility. It becomes apparent that researchers use indicators from one or two of these categories but rarely all three together. It is however important to include every category to embrace the complexity of the concept. The tables below present the indicators that have been used in the literature. This section will now define each category and its accompanying indicators.

2.2.1 Transport affordability

The first category is affordability, which refers to the financial ability to purchase transport from one place to another (Kelly et al., 2023; Lucas et al., 2016; MeJía Dorantes & Murauskaite-Bull, 2022). In the context of transport poverty, it is the lack of the financial ability, which refers to the individual being forced to disburse more on travel than he or she can reasonable afford (Lucas et al., 2016). A concept which is often associated with transport affordability is forced car ownership. This means that a person is indirectly forced to purchase a car because there are no suitable transport alternatives or the destinations are too far away (Kelly et al., 2023; Lucas et al., 2016). The forced car ownership results in a financial burden which the individual cannot afford. The trade-off between housing- and transport costs is also an affordability phenomenon, especially for low-income households. They are forced to relocate to more rural areas due to increasing living costs and are faced with less transport alternatives and higher transport costs (Allen & Farber, 2020b; MeJía Dorantes & Murauskaite-Bull, 2022; Sterzer, 2017).

Alonso-Epelde et al. (2023) creates a framework which can be applied over time and in different countries. It includes indicators from the household budget survey to perform the analysis. The quantification of transport poverty risk is done using thresholds such as the amount of expenditure devoted to transport and disposable income after transport costs. Kelly et al. (2023) also includes affordability indicators as both fuel costs and public transport costs to assess both private and public transport. These indicators are combined with mobility and accessibility indicators to create a Transport Poverty Risk Index.

Table 2: affordability factors used by the literature.

	Factor	Source
Transport affordability	Public transit cost	(Alonso-Epelde et al., 2023; Kelly et al., 2023)
	Transport expenses	(Alonso-Epelde et al., 2023; Lowans et al., 2023; Lucas et al., 2016)
	Income after transport costs	(Alonso-Epelde et al., 2023)
	Forced Car Ownership	(Kelly et al., 2023; Lucas et al., 2016)

2.2.2 Transport mobility

The second category of indicators to assess transport poverty risk is mobility. Transport mobility refers to the realization of the individual's transportation behavior. It includes the ownership of the different modalities and the resulting distance and time from the transportation (Kelly et al., 2023; Lucas et al., 2016; MeJía Dorantes & Murauskaite-Bull, 2022; Verhorst et al., 2023).

There are a number of scientific papers that study the importance of mobility and the different modalities. They also capture effects of personal attributes on the mobility aspects and its modalities. Mobility does not only represent the physical availability of transportation, but also whether the modality is accessible specific to a persons' needs. People who are older or have disabilities therefore experience more transport barriers than others and therefore have different mobility needs (Kelly et al., 2023; Lucas et al., 2018; MeJía Dorantes & Murauskaite-Bull, 2022; van Dülmen et al., 2022). Rural areas also influence the mobility needs of an individual, these areas are generally less accessible by public transit areas, making them much more car dependent (Allen & Farber, 2020a; Lowans et al., 2023; Pot et al., 2023; van Dülmen et al., 2022). This means a high reliance on the car as transportation to essential destinations. In rural areas public transport is scarce, unreliable or does not exist (MeJía Dorantes & Murauskaite-Bull, 2022). These individuals and households are therefore forced to purchase a car in order to participate in society. However, this financial burden can be too large for many low-income groups, which affects other areas in their lives (Lunke, 2022; Pot et al., 2023; van Dülmen et al., 2022). Car dependency can thus result in the concept of 'forced car ownership'. Car-ownership can also increase the chances to access the job market for low-income groups living in rural areas (MeJía Dorantes & Murauskaite-Bull, 2022). Not only rural areas are at risk of forced car ownership. European citizens often live in cap-dependent cities, with decades of car-oriented urban development (Mattioli, 2021).

Van Dülmen et al. (2022) study the mobility movements of three social disadvantaged groups in rural areas using GPS trackers. The study finds that the car was not only a transport variable, but socially conditioned variable. This shows the importance of the car for not only for accessing destinations but also participating in society. However, due to low income, people have to choose more often for public transport for commuting. This tends to result in longer travel times and higher travel congestion (Shi et al., 2022). In the Netherlands and especially in urban areas, the bicycle is also an important mode of transportation. Studies have found that the bicycle often mitigates the effect of transport problems if the travel distances are small (Martens, 2013; Pot et al., 2023).

Another method to measure transport mobility is to assess the transport activity resulting from the transportation. This includes travel distance, travel time and modality use. A number of papers use these ex-post measurements to analyze transport poverty (Allen & Farber, 2019, 2020b; Hine & Mitchell, 2017; Kelly et al., 2023; Lucas et al., 2016; Lunke, 2022; Shi et al., 2022). This seen as an effective method as travel distances and time also tend to be much higher in rural areas in comparison to the cities (Allen & Farber, 2020a; Lucas et al., 2018; Pot et al., 2023; van Dülmen et al., 2022; Velaga et al., 2012). A situation where an individual who lives in a rural area does not have high travel times and travel distances, could be an indicator that this individual is not able to access essential destinations. Important to note is that this individual could have different transport needs which could also explain the lower travel distances and travel time. Therefore, these values could give an indication.

Table 3: mobility factors used by the literature.

	Factor	Source
Transport mobility	Vehicle ownership	(Allen & Farber, 2019, 2020a; Kelly et al., 2023; Lowans et al., 2023; Martens, 2013; Mattioli, 2021; Pot et al., 2023; Shi et al., 2022; van Dülmen et al., 2022; Wu & Hine, 2003)
	Distance travelled	(Hine & Mitchell, 2017; Lucas et al., 2016, 2018; van Dülmen et al., 2022)
	Travel time	(Allen & Farber, 2019, 2020b, 2020a; Hine & Mitchell, 2017; Kelly et al., 2023; Lucas et al., 2016; Lunke, 2022; Shi et al., 2022)
	Modality use	(Alonso-Epelde et al., 2023; Pojani et al., 2017; Pot et al., 2023; van Dülmen et al., 2022)
	Ability to use the physical and digital network	(Bastiaanssen, 2012; Kaufmann et al., 2004)
	Ability to repair the modality	(Bastiaanssen, 2012; Kaufmann et al., 2004)

2.2.3 Transport accessibility

The third category of indicators, transport accessibility, can be defined as the distance and availability for an individual to access key services or destinations such as employment, education or recreation (Cohen, 2020; Kelly et al., 2023; Lucas et al., 2016; MeJía Dorantes & Murauskaite-Bull, 2022). This includes both the land-use of infrastructure such as motorways, train tracks and bicycle lanes as well as the accessibility of the transport system network. Commuting activities from and to employment is a universally used form of travel and is therefore important measurement for the level of transport poverty risk. This is acknowledged by a number of papers (Allen & Farber, 2020b, 2020a; Lunke, 2022; Shi et al., 2022). As employment opportunities are generally located in the central business districts, residents in rural areas are more at risk due to longer travel times and distances (Kelly et al., 2023). Individuals in the lower income spectrum who were indirectly forces to relocated to the peripheries of the urban areas, also tend to be more at risk. In these areas public transport accessibility also tends to be lower as there

are less bus-, tram- and metro stops and train stations. This makes public transport accessibility an important indicator for assessing transport poverty risk.
Another effective way of assessing the accessibility is examining the destination accessibility instead of the transport accessibility (Lucas et al., 2018; Pot et al., 2023; Verhorst et al., 2023). In other words, how close by are the key destinations such as employment, education or recreation. The combination of less activity opportunities and poor public transport accessibility can result in higher car dependency. This especially influences people with a lower income who cannot afford a car. Transport inaccessibility can directly cause social-exclusion and influence peoples' well-being (Awaworyi Churchill & Smyth, 2019; Lucas et al., 2016).

The Netherlands Environmental Assessment Agency (in Dutch: Planbureau voor de Leefomgeving) developed a method to calculate the accessibility of essential destinations such as schools, supermarkets and employment. This method includes every modality and also takes the different times of day into account. For example, at five o'clock in the afternoon it will be highly congested on the highway and at train stations. The research concluded that cities have the highest accessibility and that the high number of available destinations and employment are significantly more important than the lower congestion in rural areas (Bastiaanssen & Breedijk, 2022). This study provides a clear method to identify the accessibility inequity between the city and rural area. The results confirm the assumption that rural areas have higher travel distances and lower number of alternatives of facilities. The results can however not be translated into a quantification of transport poverty. It is unclear whether the individuals in these areas are actually unable to reach these activities or whether they are in fact satisfied with the lower number of alternatives.

Table 4: accessibility factors used by the literature.

	Factor	Source
Transport accessibility	Employment accessibility	(Allen & Farber, 2020b, 2020a; Lunke, 2022; Shi et al., 2022)
	Public transit accessibility	(Allen & Farber, 2019, 2020a; Kelly et al., 2023; Lowans et al., 2023; Lucas et al., 2016, 2018; Shi et al., 2022; Verhorst et al., 2023)
	Activity participation	(Allen & Farber, 2020a; Hine & Mitchell, 2017; Kamruzzaman et al., 2016; Lucas et al., 2018; van Dülmen et al., 2022)
	Activity accessibility	(Lucas et al., 2018; Pot et al., 2023; Verhorst et al., 2023)

2.2.4 Socio-demographic attributes

Personal attributes have an important role in explaining the distribution of transport poverty risk in society and effect the transport affordability, mobility and accessibility of an individual.

Household size, age, employment status and residence area are attributes that effect the mobility and accessibility needs of an individual. Households with more children might need the flexibility of a car which may lead to high transport costs, which they might not be able to afford (Allen & Farber, 2020a; Pot et al., 2023; van Dülmen et al., 2022). This is especially true for single-parent household. Individuals with employment generally need to commute to and from work which automatically increases their

mobility needs. Older people are also seen as a group at greater risk for transport poverty as they may need special mobility, cannot drive anymore or cannot use active mobility such as walking or cycling (MeJía Dorantes & Murauskaite-Bull, 2022; Ravensbergen et al., 2022; van Dülmen et al., 2022).
Attributes like migration background, gender and level of education are also important to explain the levels of transport poverty risk of an individual. Women have different mobility needs and mobility behavior than men on average (Pojani et al., 2017). Historically, cities are developed with a masculine vision on mobility practices, transport systems and the built environment. Women participate in more care-oriented trips, such as shopping for groceries or bringing the children to school. Women are therefore dependent on more destination than men. They travel longer trips but divides intro shorter, more complicated routes. Women also have a greater awareness of sustainability of travel modes and therefore travel more with public transport than men (MeJía Dorantes & Murauskaite-Bull, 2022). Lastly, women are paid less than men for the same job and more often have temporary or part time work. This results in lower financial capacity to purchase transportation.

Another key factor in transport poverty risk is income. Low-income groups are widely recognized for being directly and significantly more at risk of transport poverty (Allen & Farber, 2019; Kelly et al., 2023; Lowans et al., 2023; Lunke, 2022; Shi et al., 2022; Sterzer, 2017). Low-income households lose flexibility in multiple areas to ensure reliable transportation and reasonable travel times and travel distances. It directly shows the ability and flexibility to purchase transportation from one place to another. Individuals with low-income may not afford to purchase a car or are indirectly forced to do so because of missing mobility alternatives. Groups with lower income are often located in the more rural areas, which already results in lower accessibility and poor time competitiveness of public transport (Lunke, 2022). In addition, lower income groups have generally lower car availability, which increases the risk of transport poverty even more (Shi et al., 2022; van Dülmen et al., 2022). Housing is another aspect in which low-income groups lose flexibility. They do not have the financial freedom to choose their residential area by assessing the level of accessibility (Sterzer, 2017).

The comparison of city versus countryside or urban versus rural has a prominent seat in the literature (Allen & Farber, 2019, 2020a; Kelly et al., 2023; Lucas et al., 2018; Lunke, 2022; Pojani et al., 2017; Pot et al., 2023; Shi et al., 2022; Sterzer, 2017; van Dülmen et al., 2022; Velaga et al., 2012). Rural areas are often defined as areas with low population density. This means that the absolute demand of transport is lower in these areas. Investments in collective transportation such as public transport is therefore far less than in urban areas (*Dorantes*). There are fewer public transport services, of lower quality and lower frequency in rural areas (Allen & Farber, 2020a; Lucas et al., 2018; Velaga et al., 2012). This results in longer travel distances and travel times for the individuals that live in these areas. This also shows that car ownership is often essential to participate in society (van Dülmen et al., 2022). Car mobility is currently the most important factor in the keeping the perceived accessibility from dropping in rural areas (Pot et al., 2023). Interestingly, the research of Pot found that the perceived accessibility in rural areas is less that one might think (12%) due to the high use of the car against the perceived transport poverty in cities (8%). The car gives individuals enough opportunities to access essential destinations (Pot et al., 2023). Anti-car policies will therefore affect the people living here the most (Lunke, 2022). However, these policies may be essential in achieving the climate goals of the European Union and the Netherlands. The literature shows that the area of residence plays an important part in the accessibility and affordability needs. Residents of rural areas have higher transport costs, lower public transport accessibility and lower employment accessibility than residents of urban areas (Lucas et al., 2018; MeJía Dorantes & Murauskaite-Bull, 2022; Pojani et al., 2017; Shi et al., 2022; Van Der Bijl, 2020; van Dülmen et al., 2022).

It is clear that there are different combinations of attributes which influence the affordability, accessibility and mobility. A single mother that has a relative low education level and lives in the countryside has different experiences and needs than a man who lives on his own, has a good job and lives in the city. It is important to differentiate these individuals with varying attributes and asses what their experiences and needs are surrounding transport affordability, accessibility and mobility. This can result in different situations for different people. The table below presents the socio-demographic attributes that have been used by the scientific literature.

Table 5: socio-demographics used by the literature.

Socio-demographic variables	Source
Household size	(Awaworyi Churchill, 2020; Awaworyi Churchill & Smyth, 2019; Lowans et al., 2023; Lucas et al., 2018; Lunke, 2022; Pot et al., 2023; Shi et al., 2022; Sterzer, 2017; Verhorst et al., 2023)
Migration background	(Allen & Farber, 2019; Alonso-Epelde et al., 2023; Awaworyi Churchill, 2020; Awaworyi Churchill & Smyth, 2019; Lunke, 2022; Martens, 2011a; Pot et al., 2023)
Gender	(Alonso-Epelde et al., 2023; Lowans et al., 2023; Lucas et al., 2018; Martens, 2013; Pot et al., 2023; Shi et al., 2022; Sterzer, 2017; van Dülmen et al., 2022; Verhorst et al., 2023)
Age	(Alonso-Epelde et al., 2023; Awaworyi Churchill, 2020; Awaworyi Churchill & Smyth, 2019; Lowans et al., 2023; Martens, 2013; Pot et al., 2023; Shi et al., 2022; van Dülmen et al., 2022; Verhorst et al., 2023)
Education	(Allen & Farber, 2019; Alonso-Epelde et al., 2023; Awaworyi Churchill, 2020; Awaworyi Churchill & Smyth, 2019; Lucas et al., 2018; Shi et al., 2022; van Dülmen et al., 2022; Verhorst et al., 2023)
Employment status	(Allen & Farber, 2019; Alonso-Epelde et al., 2023; Awaworyi Churchill, 2020; Awaworyi Churchill & Smyth, 2019; Lowans et al., 2023; Pot et al., 2023; van Dülmen et al., 2022; Verhorst et al., 2023)
Income	(Allen & Farber, 2019, 2020a; Awaworyi Churchill, 2020; Awaworyi Churchill & Smyth, 2019; Lunke, 2022; Martens, 2013; Pot et al., 2023; Shi et al., 2022)
Area of residence	(Lowans et al., 2023; Pot et al., 2023; Sterzer, 2017)

2.3 Conceptual model of transport poverty risk

The categories of affordability, accessibility and mobility and the indicators within are often associated with each other and need to be combined in an analysis to be able to embrace the complexity of transport poverty. Analysis which for example only takes accessibility into account can ignore people that are at risk due to affordability issues. This becomes especially apparent when including socio-demographics of individuals. People with low-income but who live in the city may not be labelled as transport poor when only taking accessibility into account. However, their low-income does leaves them more vulnerable. Transport poverty risk can be explained by a combination of the categories. For example, a single mother who lives in a rural area may experience both affordability and accessibility poverty. The conceptual model of transport poverty needs to combine affordability, accessibility and mobility with their associating indicators along with the socio-demographic attributes of an individual. It is important to differentiate the three categories but to emphasize the areas in which they meet. The categories are independently not able to sufficiently assess the risk of transport poverty. Only when an individual is vulnerable in two areas, is he or she more at risk of transport poverty or transport problems. For example, an individual lives in a rural area and has low accessibility to public transport and destination. This can be compensated by the fact that this individual is financially able to afford the mobility of a car to drive to these destinations which are further away. The figure below shows the conceptual model of this research.

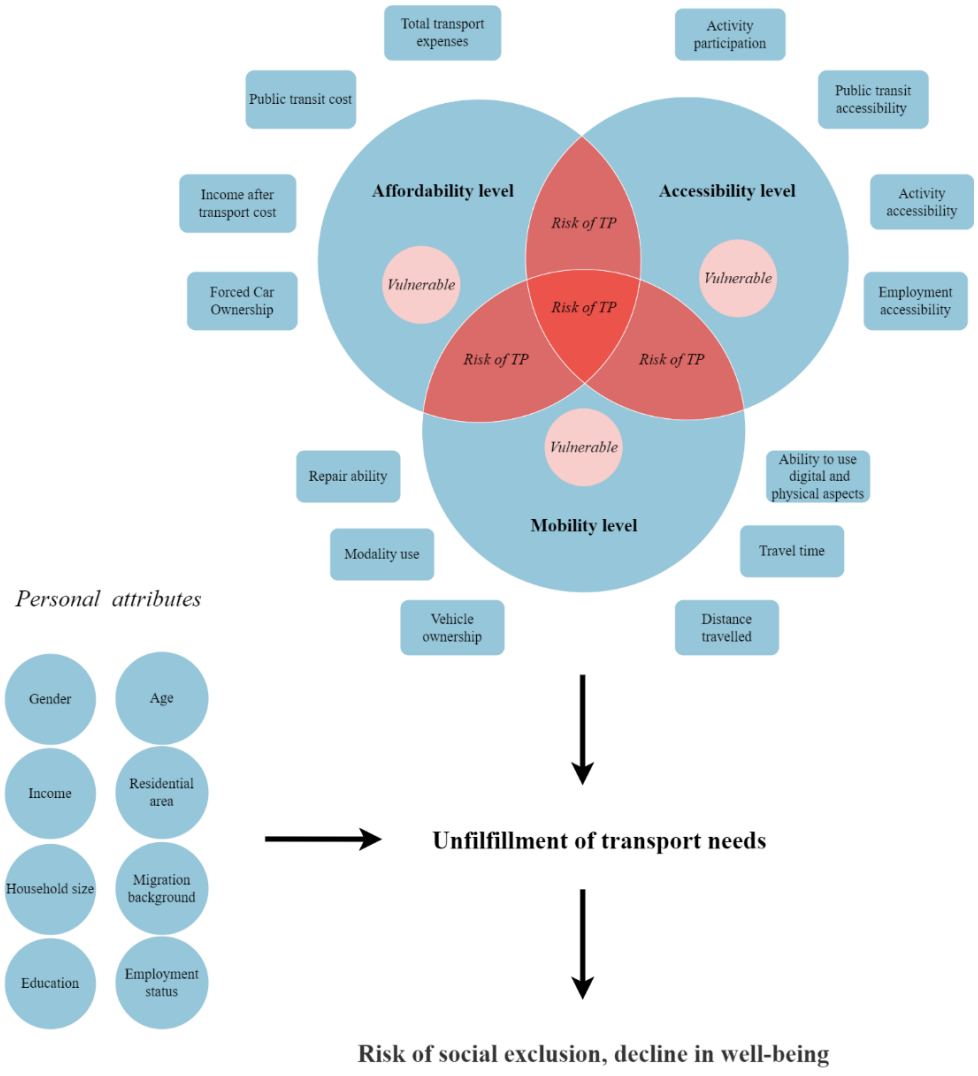

Figure 3: transport poverty risk conceptual model by the author.

3. Methodology

The third chapter presents the methodology approach of this research. The utilization of multiple approaches by this research is the reason that a general approach is specified and visualized. After establishing the general approach, this chapter continues to present and provide a detailed explanation of the two national surveys and concludes with an elaboration on the Latent Cluster Analysis methodology.

3.1 Overview

In this section, the general approach is outlined with the different research objectives and methods. The first objective is to identify which indicators in the conceptual model are also available in the MPN and ODiN surveys for the Latent Cluster Analysis model. This is done in the next chapter. The Latent Cluster Analysis method is used to construct the transport vulnerability groups and to identify potential transport disparities in the Netherlands. Past literature has conducted analysis on transport poverty risk using a limited number of pre-selected variables. A Latent Cluster Analysis approach allows this research to construct groups based on post-hoc data. This means that the groups are created by the values from a wide range of indicators from the national dataset and not by predetermined assumptions. This will potentially reveal an accurate representation of transport inequality which allows policymakers to design more effective policies.

The identification of potential vulnerabilities and therefore the use of the MPN dataset, has its limitations. The dataset is unable to assess where these essential destinations for a particular person are and whether that person was able to access these destinations. In other words, the MPN dataset in unable to identify whether individuals experience transport problems. This limitation is addresses by the ODiN survey. The ODiN surveys contains question on the individuals' ability to access certain essential locations, such as the supermarket, doctor or family. The MPN surveys does, however, contain questions on the individuals' overall satisfaction of their overall mobility and ability to fulfill their daily activities. Although these satisfaction indicators are not included in the conceptual model of transport poverty risk and cannot solely assess an individual's transport vulnerability, it is interesting to investigate how the objective indicators and thus the potential transport vulnerabilities influence their overall mobility satisfaction. The research on the transport inequality between and the transport vulnerability within groups is done by combining three approaches. The first approach is to use the complexity of the transport poverty risk indicators in the MPN to construct the groups. The second approach is integrating ODiN to assess the ability of groups to access certain essential locations. The third approach is to include the MPN satisfaction questions to indicate the relation between the objective indicators and the overall mobility satisfaction. The visualization of the general approach is presented in figure 4.

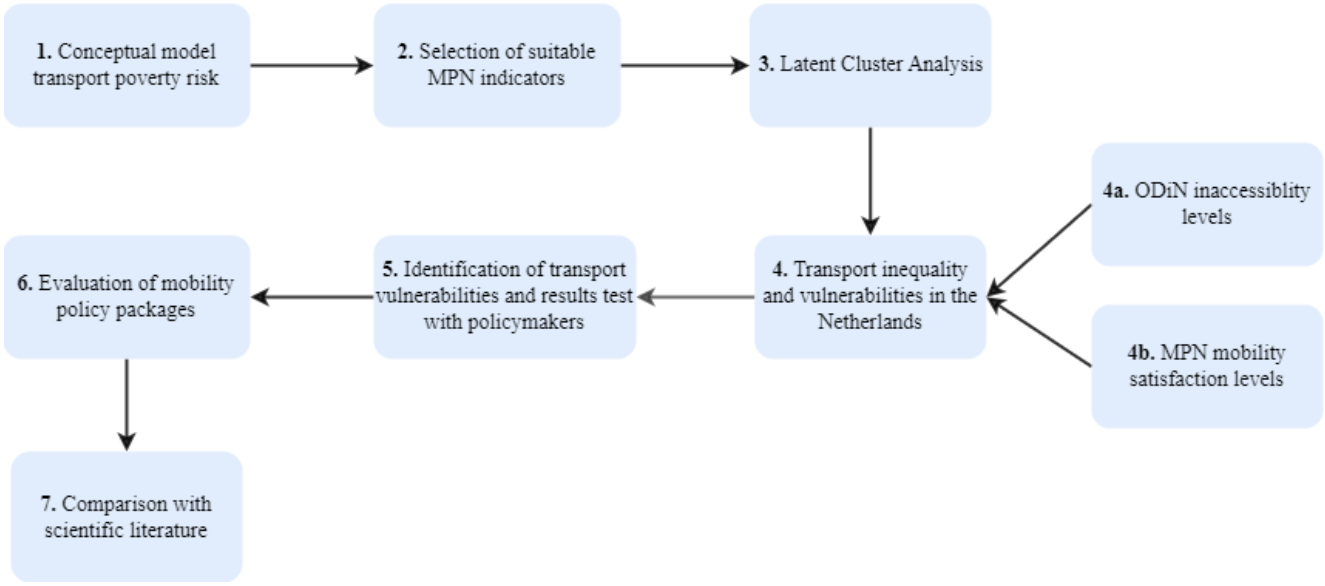

Figure 4: general approach diagram.

3.1.1 ODiN integration

The ODiN dataset will provide this research the ability to identify whether individuals have had past transport problems. The respondents were asked how often they were able to access destinations such as school, doctor, hospital, train station or family. This question can directly provide an indication to what extent a group of individuals were not able to access destinations in the past, providing additional evidence on the transport problems. The ODiN dataset however does not allow for conducting a LCA due to the lack of sufficient affordability, accessibility and mobility indicators. It is therefore necessary to integrate the ODiN respondents using the groups acquired through the MPN data. The method is formulated as follows. The MPN data provides indicators to conduct the LCA and construct complex transport groups. The socio-demographic attributes are then used to identify what kind of individuals are parts of each group. The ODiN data includes the same personal attributes as the MPN, which paves the way for the integration. The LCA contains a formula to calculate the probability for every group that an individual is part of that groups according to the personal attributes. The individual is then assigned to the group which has the highest probability. The following formula is used to calculate the probability given one attribute:

$$\hat{\pi}_t^{X|z_1} = \frac{exp(\gamma_{t0}^X + \gamma_{t1}^X z_1)}{\sum_{t'=1}^{T} exp(\gamma_{t'0}^X + \gamma_{t'1}^X z_1)}$$

Where γ_{t0}^{X} is the intercept value of cluster x and $\gamma_{t1}^{X} z_1$ the intercept value of the covariate of cluster x. In this research, eight attributes are included in the calculation. The household income attribute did not allow for integration between the two datasets. Therefore, the average income in the ODiN dataset is used for every individual. The results are presented for every group and for every destination. The results provide a percentage of individuals of every group who have experienced problems accessing a destination.

This integration does highlight a number of uncertainties. Firstly, individuals are placed in the group for which he or she has the highest probability. However, because of the large number of groups, the probabilities can be close to each other. This means that the placement of the individuals in the groups

can be uncertain. This shows the limitation of LCA that there are no absolute numbers of individuals per cluster. Secondly, the average income of the ODiN respondents is used due to the inability to integrate the income variables between the two datasets. This results in misrepresentations of the probabilities. The probability of being included in a group in which individuals have a relatively low income, is lower due to the average income being higher.

3.1.2 Satisfaction questions in the MPN

The MPN survey also includes two questions which provide an indication on the individual's overall mobility satisfaction. The questions are formulated around the overall satisfaction of respondents. The first question is formulated: "All in all, are you satisfied with how you can get around?". The second question is formulated: "Can you easily perform all your desired daily activities?". The answered to these questions can give an estimate on the overall level of transport problems of an individual. However, the questions do not specify why the individuals is not satisfied. There are two options for combining the subjective satisfaction indicators with the objective transport poverty risk indicators. The first option is to first, use the satisfaction indicators to construct the latent groups and then integrate the objective indicators to determine the reasons behind the satisfaction levels. The second option is to first use the objective indicators to construct the latent groups and then integrate the satisfaction indicators. This research will use the second option as it corresponds with the theoretical model, and it can capture interesting relations between levels of transport poverty risk and satisfaction. The first option will not allow to include the entire complexity of the concept. It is thereby important to acknowledge that the level of mobility satisfaction is not a sole measure of success. The level satisfaction can be dependent on a wide range of indicators. Not including these indicators and the relation with the satisfaction levels carries the risk of oversimplification. This research advocates for a broader approach that contains the entire complexity of transport inequality and transport poverty risk.

3.1.3 Consultation with policymakers

After acquiring the groups of individuals resulting from the Latent Cluster Analysis, this research will conduct consultations with policymakers with expertise in the field of transport poverty and transport inequality. The consultation is done with two policymakers who are actively working on transport inequality and transport poverty risk on national level. The consultation and feedback will produce an indication whether the data effectively represents the societal problem. This will also imply the usefulness of the results for the next phase, policy evaluation. Hence, this research needs the expertise of the policymakers to test the applicability of the groups to actual society. The first step introduces the policymaker to the research. The motivation and the relevance of the research should be explained as well as a simple explanation of the research methodology. In the second step, the policymaker will be presented with the results. This will be done using visualizations to simplify interpretation. The aim is to translate the relative differences in the values scored by the groups on the indicators, into vulnerabilities the eyes of the policymakers. In other words, the policymakers are asked to translate the results to society in order to identify the potential transport vulnerabilities for every group. In the last step, the policymakers will be asked to reflect on the results of the analysis. Whether they recognize the societal problems surrounding transport poverty risk or whether they think groups are missing from the results.

3.1.4 Policy thought experiment

The last phase in the general approach is the policy thought experiment. After the consultation on the groups by the policymakers, the groups will be applied to evaluate potential policy interventions. The policy interventions should not be too far into the future as the groups could also change in the future

thus resulting in misinterpretation. The goal of applying policy interventions is to indicate the positive of negative effect of the intervention on the potential transport inequality in the Netherlands. Therefore, this phase could provide policymakers with a thought experiment to evaluate their policy concepts. In light of the ongoing government formation process, the mobility policy packages of three important parties will be used in the evaluation. Based on the policies and the indicators on which the policies will apply, the groups can be used as a qualitative indication on the effect on transport inequality. For example, one party aims to decrease the fuel price for the car. Then looking at the amount of car use of the groups, the effects on the inequality can be reasoned. The policy thought experiment can be structured with the following questions that need to be answered:

1. What is effect of the policy on the latent groups? (For example, improved car affordability)
2. Is this effect proportionally similar among the affected groups? If not, why? (For example, due to the variation in car use).
3. How does this influence the overall transport inequality between the latent groups?

3.2 The MPN and ODiN survey

This research will contain two datasets with each their own purpose, advantages and limitations. The first data set is from the Netherlands Mobility Panel (MPN). The MPN studies the travel behavior of a fixed group of individuals and household over a longer period of time (MinIenW, 2022). The study is carried out every year by the Netherlands Institute for Transport Policy Analysis which is an organization part of the Dutch Ministry of Infrastructure and Water Management. The respondents are asked to keep track of their mobility behavior for three days, including modalities, motivations and costs (MinIenW, 2020). Respondents are also asked to fill out an extensive survey regarding their personal and household information. The goal of the MPN is to uncover information on trends in human behavior, habits, the effects of life events and enable travel choice models. For the reason that the MPN is a panel survey, the survey allows for the investigation on effects of events, policies or other societal changes on mobility throughout the years. More information on the Netherlands Mobility Panel can be found in Hoogendoorn-Lanser et al. (2015). This research will use the MPN data to establish the different potential transport vulnerability groups. The MPN 2022 has a sample size of around 5700 respondents, which is 0,03% percent of the population. The data contains suitable indicators for all three transport poverty categories: affordability, accessibility and mobility. The MPN data is able to capture the complexity of the concept with both personal and household information. The limitation of this dataset is the lack of specific transport poverty questions. An answer to the question whether someone was not able to access essential destinations and therefore has experienced transport problems will not be provided by the MPN data. The data will however be able to potentially capture groups of individuals who are more at risk of transport poverty.

The second dataset that this research will use is from the 'Onderweg in Nederland' (ODiN) survey. The ODiN survey is carried by the Central Bureau of Statistics and also examines the daily mobility behavior that Dutch citizens (CBS, 2023a). In addition, the ODiN contains questions relevant to the political trends at the time. The target population of ODiN consists of all persons living in the Netherlands in private households and are ages six years and older. The basis for sampling is the Basic Registration of Persons (BRP). The sampling is done in two stages. In the first stage, for every COROP region the municipalities are picked systematically based on a probability proportional to their inhabitants. The second stage is a random sample in the selected municipalities. The eventual sample size of ODiN 2022 is around 62000, which is 0,4% of the Dutch population. The first sample size is larger than the eventual sample size due to respondents who do not complete the screening. For this research, ODiN is not capable of establishing the transport vulnerability groups due to lack of suitable indicators that capture the complexity. However, in filling out the ODiN survey, the respondents are asked to answer one important question. The question is whether the respondent was able to access all the essential destinations. The answer to this question is a direct indication of whether the respondents were transport poor. This research will therefore combine the MPN data with the ODiN data to both assess the transport poverty risk of different groups and to indicate whether these groups were able to access essential destinations in the past.

3.2.1 Limitations of the datasets

Both the MPN and the ODiN survey have two important limitations that need to be addressed. These limitations are especially important when regarding the nature of this research. The MPN and the ODiN surveys are both conducted via a computer with an internet connection. Both surveys are also only available in the Dutch language. The reason for this is that the surveys need to be a correct representation of the Dutch citizens, key word being Dutch. Conducting the survey digitally creates many advantages for the survey such as real time assessment of the answers. However, in this research which focusses on transport disparities, the small groups of disadvantaged individuals are an important part. The digital and

language disadvantaged are prone to face more transport vulnerabilities. To use the public transport network, shared mobility or even order a taxi, some form of digital knowhow is necessary. The Dutch language is also evident in the public transport network. To not include these two groups in the survey, is a limitation for this research.

3.3 Latent Cluster Analysis

This research uses Latent Cluster Analyses (LCA), also known as Latent Class Cluster Analysis (LCCA) as the statistical method to identify the transport vulnerability groups in the Netherlands. LCA is defined as a method for modelling a discrete latent variable using multiple, discrete observed variables as indicators (Araghi et al., 2017; Lezhina & Kismihók, 2022; Magidson & Vermunt, 2004). In other words, it is a classification procedure that allows researchers to categorize individuals into homogeneous groups, assumed that individuals share certain outward characteristics (Araghi et al., 2017; Clark & Muthén, 2009; Mindrila, 2020; Oberski, 2015; Weller et al., 2020). The structure of the latent groups is estimated based on the variance shared by these indicators while maximizing the heterogeneity between the groups (Lezhina & Kismihók, 2022; Weller et al., 2020). The goal is to find the 'best' model with the smallest number of latent classes (Araghi et al., 2017; Kent et al., 2014; Molin et al., 2016). The idea is that the latent variable can account for the observed correlations between the indicators such that these correlations become insignificant. This is called the local independence assumption (Araghi et al., 2017; Lee et al., 2020; Magidson & Vermunt, 2004; Molin et al., 2016; Weller et al., 2020).

LCA is a model-based clustering method that consists of a measurement model and a structural model. The measurement model includes the latent variable and the observed indicators. It "measures" the presumed latent groups based on the indicators (Lee et al., 2020; Mindrila, 2020). LCA is a person-centered approach with a structural model. The structural model consists of the latent variable and the personal attributes, also defined as 'covariates'. The covariates can explain what kind of individuals in terms of attributes such as age, gender and income, are included in a particular latent class (Magidson & Vermunt, 2004). The individuals are placed in the groups based on the class membership functions. These functions probabilistically assign individuals to the latent groups (Clark & Muthén, 2009; Lee et al., 2020; Magidson, 2002; Oberski, 2015; Weller et al., 2020). The use of the measurement as well the structural model, allows researcher to both perform classification and cluster description simultaneously.

3.3.1 Advantages and limitations

In contrast to the more traditional clustering methods which are distance based, LCA uses a model-based clustering method (Kent et al., 2014; Lezhina & Kismihók, 2022; Magidson, 2002; Molin et al., 2016). The distance-based method uses dissimilarity criteria to assess the distance between cases. The means of the variables are used to assess the "nearness" of cases and assign them to a cluster (Kent et al., 2014; Lezhina & Kismihók, 2022; Weller et al., 2020). Using a model-based approach has several advantages when compared to distance-based methods (Magidson, 2002). Firstly, LCA reduces misclassification bias (Araghi et al., 2017). This is mainly because of the posterior membership probabilities which classify the individuals into groups.

Secondly, LCA provides a number of criteria for identifying the optimal number of classes (Araghi et al., 2017). For LCA, the Bayesian Information Criterion (BIC) is often used as the criterion (Araghi et al., 2017; Lezhina & Kismihók, 2022; Magidson & Vermunt, 2004; Mindrila, 2020; Weller et al., 2020). Other criteria are Integrated Completed Likelihood (ICL), ASW, a criterion traditionally used for selecting the number of groups in distance-based method and the Akaike Information Criterion (AIC). To obtain the optimal number of classes and to conduct the LCA, the procedure is to run a sequence of

models. Starting with a model with only one latent class and with each step adding one more class until the model fit does not improve (Weller et al., 2020).

Thirdly, it is not necessary to standardize all the variables in order to avoid the results being dominated by the variables with the most variation (Magidson, 2002).
Fourthly, variables of mixed measurement levels can be incorporated, so both continuous and categorical (Araghi et al., 2017; Kent et al., 2014; Magidson, 2002). This is an important advantage which greatly improves the flexibility of the clustering approach, as it allows the researcher to incorporate more indicators and improve the complexity and validation of the groups.

Lastly, the statistical significance of the acquired model parameters can be computed and assessed. This allows the researcher to potentially generalize the findings in the sample to the population (Araghi et al., 2017).
One of the advantages of the LCA is also a potential limitation: the local independence assumption (Lee et al., 2020). The indicators used in this research may correlate (Asparouhov & Muthén, 2011). It is important to assess the correlations between the indicators before performing the LCA. Another limitation is that definitive class assignment cannot be guaranteed due to the probabilistic assignment of individuals in the groups. This also results in the limitation that the exact number of members of each cluster cannot be defined (Weller et al., 2020). It is important that the researcher clearly specifies the names of each cluster. Due to the complexity of the potential transport vulnerability groups, the groups are prone to “naming fallacy” (Weller et al., 2020). The researcher is advised to specify the criteria used to name each cluster and use the same criteria for each cluster.

4. Data analysis and model specification

The fourth chapter of this research constructs the model of the LCA. In order to do so, the indicators of the MPN dataset that suitable for the analysis are selected and specified. This is done using the conceptual model of transport poverty risk which is presented in chapter 2. The MPN and ODiN samples are analyzed suing a descriptive analysis. The shortcoming of the MPN indicators and MPN and ODiN samples are also clarified. A correlation analysis is conducted to remove any indicators which could negatively influence the outcomes of the LCA. This chapter concludes with the presentation of the conceptual LCA model and the selection of the optimal number of groups.

4.1 Indicators and personal attributes in the MPN survey

The conceptual model in section 2.4 presents the indicators of transport poverty and socio-demographic attributes which have been used in the scientific literature. The MPN dataset contains a satisfactory number of indicators that are closely related to the conceptual model. The MPN dataset also contains almost every socio-demographic attribute that has been used in the scientific literature. It is important that these personal attributes are also in the ODiN dataset to be able to combine the two datasets after performing the LCA. The tables below show the indicators and socio-demographic attributes that are included in the MPN dataset and are eligible to be part of the LCA.

4.1.1 MPN mobility indicators

The first set of indicators represent the mobility aspect. The conceptual model presents the four main indicators which have been used by the literature. These are: vehicle ownership, distance travelled, travel time and modality use. The MPN dataset has indicators which measure the ownership and use of every modality. Travel distance as a car driver is also included, however travel time is missing. As the distances to the public transport network and to the activities are included in the accessibility notion, the research accepts the missing of a travel time indicator. Three notable additions are health hinderance, the car availability and the e-bike use indicators. Health hinderance is included as it directly affects the ability to use a modality and so affect the potential for movement. The car availability indicator can indicate to what extent the car ownership translates in use potential. E-bike use is included to complete the bicycle use measurement.

Table 6: MPN mobility indicators.

Conceptualization reference	**MPN indicator**	**Unit**
Vehicle ownership	Person has a car	0=No, 1=Yes, 2=not any vehicle
	Person has a bicycle	0=No, 1=Yes
	Have a car available at any time	4 categories
Modality use	Frequency of car use (as driver)	1=most, 6=never
	Frequency of bicycle use	1=most, 6=never
	Frequency use of electric bicycle	1=most, 6=never
	Frequency use of bus, tram and metro	1=most, 6=never
	Frequency of train use	1=most, 6=never
	Frequency walk	1=most, 6=never
Distance travelled	Number of km driven in a car as the driver	1=lowest, 9=highest
Health hinderance	To what extent does your health hinder you from walking?	1=very much, 4=not at all
	To what extent does your health hinder you from cycling?	1=very much, 4=not at all
	To what extent does your health hinder you from driving?	1=very much, 4=not at all
	To what extent does your health hinder you when travelling with PT?	1=very much, 4=not at all

4.1.2 MPN accessibility indicators

The literature utilizes four different indicators to measure the accessibility notion. These indicators are employment accessibility, public transit accessibility, activity participation and activity accessibility. The MPN includes detailed distances to the public transport network entrances train station, tram stop, metro stop and different bus stops. The distances to the activities are added through CBS data on all the zip codes in the Netherlands (CBS, 2022b). Employment accessibility is also added through CBS data. The employment accessibility is assessed using the number of jobs within a radius of 50 kilometers. Lastly, the MPN includes two more important indicators that evaluate the overall accessibility of a region. The first is the urbanity level to indicate whether the individual lives in the city or in the countryside. The second is the distance to the nearest highway to indicate the car accessibility of a region. The conceptualization of activity participation is missing in the survey. This factor could give a direct indication whether an individual is taking part in society and is able to access the desired activities. This indication can be achieved using the ODiN integration and the use of the satisfaction factors in the MPN. It is also clear that there are a number of indicators that represent the accessibility level. It is therefore important to analyze the relations between the indicator before continuing with further research. Indicators with a large relation to another indicator can influence the results of the statistical model, which can lead to a misrepresentation of the data.

Table 7: MPN accessibility indicators.

Conceptualization reference	**MPN indicator**	**Unit**
Public transport accessibility	Straight line distance between nearest station and residential location	#m
	Straight line distance between nearest metro or express tram stop and residential location	#m
	Straight line distance between nearest tram stop and residential location	#m
	Straight line distance between nearest bus stop with at least 4 times per hour a bus and residential location	#m
	Straight line distance between nearest bus stop with at least 2 times per hour a bus and residential location	#m
	Straight line distance between nearest bus stop with at least 1 time per hour a bus and residential location	#m
	Straight line distance between nearest bus stop with at less than 1 time per hour a bus and residential location	#m
Activity accessibility	Distance to the nearest general practitioner	#km
	Distance to the nearest hospital	#km
	Distance to the nearest large supermarket	#km
Employment accessibility	Number of jobs available within 50 km	#jobs
Overall accessibility	Urbanity (municipal level)	1= very highly urbanized, 5= non-urbanized
	Straight line distance between nearest entry or exit of a highway and residential location	#m

4.1.3 MPN affordability indicators

The conceptual model presents three indicators that are used by the literature to measure the affordability notion: public transit cost, transport expenses and income after transport costs. The MPN dataset does not include specific trip costs for every individual or an indication on the amount of travel expenses. It does however include different affordability questions that were asked to the respondents. They represent the overall transport expenses, public transport expenses and the car expenses. These questions can give an indication on whether the individual spends too much on transport than he or she actually can afford.

Table 8: MPN affordability indicators.

Conceptualization reference	MPN indicator	Unit
Transport expenses	I spend more money on my travel than I can actually afford	1=completely disagree, 5=completely agree
	Actually, I can hardly afford the cost of car use	1=completely disagree, 5=completely agree
	Car ownership is a necessity, not a free choice	1=completely disagree, 5=completely agree
Public transport cost	It is difficult for me to use public transport because of the cost	1=completely disagree, 5=completely agree

4.1.4 MPN personal attributes

The MPN dataset includes every personal attribute presented in the conceptual model. There are some particulars. Area of residence is included as the COROP areas in the Netherlands. The Netherlands is divided int 40 different areas. This research assumes that this can give an accurate indication of where the respondents live. Including the residents of municipality or even zip code level, would increase the complexity of the model. The overall satisfaction of the transport abilities of the respondent is also included as a socio-demographic attribute as it can give an indication of how the three different notions translate to actual satisfaction.

Table 9: MPN socio-demographic attributes.

Socio-demographic attribute	Units
Highest completed education level	1=lowest, 8=highest
Work situation person (most applicable)	9 categories
Number of people in household	#persons
Gender	1=Man, 2=Woman
COROP area of residence	40 areas
Age	Number of years
Origin of person	1=Dutch, 2=Europe, 3=not Europe
Household income	1=least, 27=most

4.1.5 The missing parts

To evaluate the effectiveness of the MPN dataset in corresponding with the conceptual model of transport poverty risk, it is important to identify the missing parts. There are four factors in the conceptualization that are not accounted for through the use of the MPN indicators. The first is the travel time of the mobility factors. Travel time can give valuable insides into difference between for example groups with different residence areas or different modality ownerships. The dataset does include travel distance in a car as the driver which partly fills the gap of travel time. However, travel distance for the other modalities is still missing. The second missing part of the conceptualization is the activity participation of the accessibility factors. The activity participation can give a direct insight into whether individuals are able to reach their essential and desired destinations. The integration with the ODiN dataset and the inclusion of the satisfaction factors of the MPN will fill this gap and provide an indication whether an individual has experienced transport problems to reach certain activities in the past. The third missing part are the exact transport expenses per modality of the affordability factors. This also results in the missing of the income after transport expenses factors. The MPN dataset only includes broad affordability questions on the overall affordability, public transport and car affordability. This is however a perception of the individual. The dataset does not include values of how much the expenses for each individual and each modality are. This could provide valuable insides into the difference of expenses between modalities, societal groups and residential areas. This would also allow for detailed evaluation of future policy interventions regarding transport affordability.

4.2 Data preparation and analysis

This research has to prepare the data before performing the statistical analysis. The MPN dataset contains both household and personal questions. The data from each question has to be combined in one dataset. The household data has to be transferred to the personal data. For example, the household income question has the same value for both individuals in the household. Respondents who did not fill out the household and/or personal dataset questions are excluded from the dataset. Respondents younger than 18 are also excluded from the research as they are often reliant on their parents for transport and have very different transport needs then the rest of society. Lastly, cases with invalid values regarding the distances questions, are excluded from further operation. The dataset needs to be converted to a different datatype to be fit for analysis in the statistical software.

4.2.1 Data analysis

This section presents the data from the MPN and ODiN datasets. The descriptive statistics and frequencies are presented for the eight personal attributes. It is important to analyze the data that will be used, in order to identify the advantages and shortcomings. The data should be a representation of the population of the Netherlands. For example, both woman and men, old and young and residents of every region. Not identifying the shortcomings of a dataset can lead to misinterpretation of the results. These personal attributes influence the personal transport needs of the individual. It therefore also influences the indicators of affordability, accessibility and mobility.

Table 10: descriptive analysis of MPN and ODiN.

	MPN	**ODIN**	**POPULATION**
SAMPLE SIZE	*4283*	*54217*	-
AGE (CBS, 2023D)	*%*	*%*	*%*
18-29	12,1	17,9	18,9
30-40	18,4	16,3	17
41-65	41,1	37,2	39,4
65+	28,3	28,5	24,7
TOTAL	100	100	100
GENDER (CBS, 2023D)	*%*	*%*	*%*
WOMAN	53,7	49	50,3
MEN	46,3	51	49,7
TOTAL	100	100	
COUNTRY OF ORIGIN (CBS, 2023D)	*%*	*%*	*%*
NETHERLANDS	91,5	76,2	74,1
OTHER EUROPE	3,5	11,2	10,9
NON-EUROPE	3,4	12,5	14,4
UNKNOWN	1,7	-	-
TOTAL	100	100	100
HOUSEHOLD SIZE (CBS, 2023E)	*%*	*%*	*%*
1	25,1	20,2	39,5
2	41	42,2	32,4
3	12,7	14,3	11,6
4	15,4	16,2	11,6
5+	5,9	7	5
TOTAL	100	100	100
EDUCATION LEVEL (CBS, 2023F)	*%*	*%*	*%*
BASIC EDUCATION	4,0	1,4	8,3
LOWER EDUCATION	11,7	3,1	10,1
MAVO, LOWER HAVO, VWO	10,8	17,4	21,7
MBO, HAVO, VWO	38,7	31,0	22,9
HBO, WO	34,7	44,0	34,8
UNKNOWN	0,1	3,2	1,7
TOTAL	100	100	100
EMPLOYMENT STATUS (CBS, 2023C, 2023B)	*%*	*%*	*%*
PAID EMPLOYMENT	55,7	57,5	70,1
INCAPACITATED	6,1	3	5,8
UNEMPLOYED	1,7	1,4	2,7
RETIRED OR VUT	24,1	24,6	11,4
STUDENT	3,8	5,9	2,4
HOUSEMAN/HOUSEWIFE	5,5	3,8	2,1
VOLUNTARY WORK	2,1	1,7	-
UNKNOWN	0,2	-	-
OTHER	0,7	2	-
TOTAL	100	100	-
MEDIAN HOUSEHOLD INCOME (CBS, 2022A)	43.500 – 57.600	87.700	62.700
MEAN HOUSEHOLD INCOME (CBS, 2022A)	63.700	81.818	82.100

In order to identify transport inequity and transport vulnerabilities in the Netherlands, the dataset should also effectively represent the whole population of the Netherlands. There are some important findings from the descriptive analysis which need to be addresses before conducting the cluster analysis. The MPN has several deviations from the population values. Firstly, the individuals with the age above 65 are overrepresented in the sample and individuals under the age of 19 are underrepresented. Secondly, the natives are also very overrepresented in the MPN survey. The reason could be that immigrant cannot speak the Dutch language and thus not participate in the survey. Thirdly, as the MPN is a household survey, the one person households are underrepresented in the sample as there are way more multi person households. Another important factor is the education level where higher educated individuals are more present in the sample when comparing it to the population value. As for the ODiN, there are more younger individuals, and the non-Dutch individuals are more represented. However, there are still more multi person households than in the population and the education levels are higher. The amount of household income in ODiN dataset is significantly higher than in the population. A reason for this could be the underrepresentation of one person households and thus the overrepresentation of multi person households. Another reason could be the higher percentage of HBO or WO educated individuals in the ODiN survey. As presented in figure 5, the geographical distribution of the respondent in the MPN and the ODiN is comparable to the actual population density of the Netherlands.

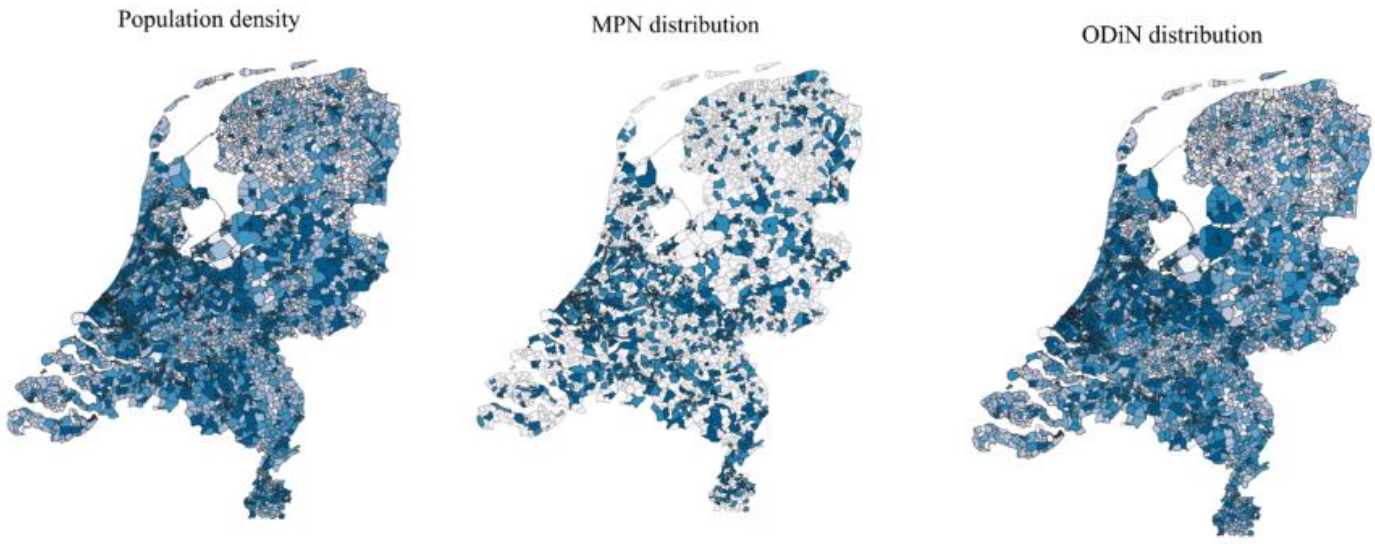

Figure 5: maps of Netherlands of descriptive analysis.

4.3 Final LCA Model

4.3.1 Correlation analysis

Before creating the model of the Latent Class Analysis for identifying the potential transport vulnerability groups, this research will conduct a correlation analysis. This has several reasons: the dataset includes a large number of potential indicators. These indicators are also theoretical related to each other, for example the distance to the nearest metro stop and the distance to the nearest tram stop are often related. This increases the risk of high correlation values between these indicators. A correlation analysis allows for assessing these correlations and evaluating which indicator to include in the LCA model. If correlations are too high between indicators, the LCA will create groups focusing on these high values, because LCA will minimize the within group correlation but allowing between group correlation. This will result in a misrepresentation: the groups will represent the data rather than reality. For example, an indicator on lung health and an indicator on the amount of smoking will most likely be highly correlated as smoking is bad for the health of your lungs, even if this was not the conceptual purpose of the model.

To include the nominal variable in the correlation analysis, it is necessary to create dummy variables. Dummy variables are binary (0,1) and can therefore be included in the correlation analysis. Spearman correlations are used in the analysis due to the ordinal variables. The correlation values should preferably be between -0.5 and 0.5 but definitely be below 0.7 or above -0,7, depending on positive or negative relationships.

The results of the correlation analysis are put in the appendix. It is clear that the spatial distances of the public transit access point are highly correlated. Some decision on which indicator to include in the LCA need to be made. Firstly, the indicator ‘straight line distance between nearest metro or express tram stop and residential location’ will be excluded from the model. The reasoning is that the distance to a tram stop will be a satisfactory indicator of the medium speed public transit accessibility. Secondly, the indicator ‘straight line distance between nearest bus stop with at least 2 times per hour a bus and residential location’ will also be excluded from the model. It correlates with multiple other indicators. Thirdly, the indicator ‘straight line distance between nearest bus stop with at less than 1 time per hour a bus and residential location’ will be excluded because it has a very high correlation with its counterpart of one bus per hour. The indicator ‘distance to nearest tram stop’ will also be excluded. Not every city in the Netherlands has a tram network. It is therefore unnecessary to assess transport problems according to the trams stops. De bus stops and train stations are a valid measurement for public transit accessibility throughout the country.

Two indicators are included as factors through a dimension reduction. Firstly, the indicator ‘mobility health hinderance’ includes survey questions about the health hinderance while travelling by foot, bike, car or public transit. These four questions are highly correlated and thus are combined in a factor analysis to explain the overall ‘mobility health hinderance’. Secondly the two car affordability survey questions are highly correlates as both indicate forced car ownership. They are combined to explain the overall ‘forced car ownership’. The rest of the correlations will be accepted due to theoretical relevance to the transport vulnerability groups. The indicators of the two factors will be included in the LCA model as inactive covariates. This means that they will not contribute to the construction of the groups or the class membership function. However, the distribution of the indicators for every group will be available and thus allow for interpretation on the values of the indicators. The reason is that the factors will be difficult to interpret but are necessary to include in the model to account for the complexity of the concept of transport poverty.

4.3.2 Model specification

Combining the theoretical background of Latent Class Analysis, the defined categories, indicators and socio-demographic attributes allows this research to design the final LCA model. This model is the theoretical reference of the statistical analysis. It contains a measurement model which includes the latent variable and the indicators, and the structural model which includes the latent variable and the covariates. The covariates affect the latent variable but do not directly affect the indicators (Vermunt & Magidson, 2016). The indicators are assumed to be mutual independent, as stated in the local independence assumption.

The mathematical representation om the measurement model is, given the above-mentioned assumptions, as follows (Vermunt & Magidson, 2016):

$$f(y_i|z_i^{cov}) = \sum_{x=1}^{K} P(x|z_i^{cov}) \prod_{t=1}^{T} f(y_{it}|x)$$

For which x is a single nominal latent, T response variables, y_{it} indicators and z_i^{cov} covariates affecting x. The structural model contains the class membership function which represent the chance than an individual, given the covariates values, is a member of a cluster. Note that this class membership function is the key to combining the MPN data with the ODiN data. The class membership function, with K classes, x latent variable, y_x the intercept value and y_{xr} the set of regression parameters, which are the effect of the covariate values, can be mathematical formulated as follows:

$$P(x|z_i) = \frac{\exp\left(\gamma_x + \sum_{r=1}^{R} \gamma_{xr} * z_{ir}\right)}{\sum_{x'=1}^{K} \exp\left(\gamma_{x'} + \sum_{r=1}^{R} \gamma_{x'r} * z_{ir}\right)}$$

The LCA model of this research is visualized in figure 4. The indicators are placed on the right side of the model with arrows coming from the latent groups. This means that the groups explain the patterns of the indicators. The three categories affordability, mobility and accessibility are also visualized using boxes with dashes lines. As explained in the method section, the groups are constructed using these patterns within the indicators. The indicators are part of the measurement model along with the latent groups. The covariates (or personal attributes) are placed on the left side of the model.

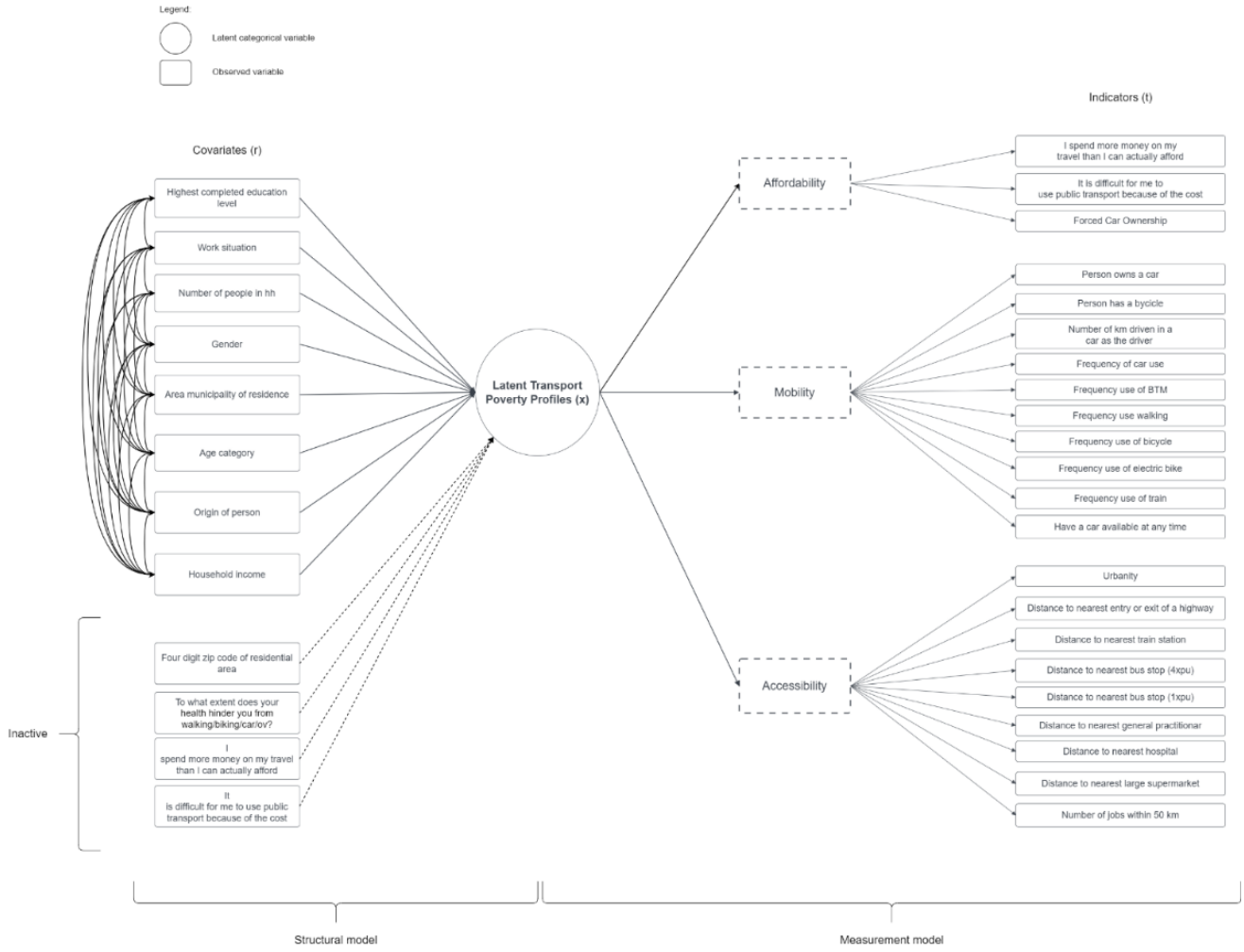

Figure 6: Latent Cluster Analysis model by the author.

The covariates have arrows going to the latent groups. This means that the covariates explain the type of individual that is part of each group. These covariates are potentially correlated with each other and thus have arrows going to each of the boxes. The covariates along with the latent groups form the structural part of the model. The model also includes a number of inactive covariates. These are covariates which are not part of the statistical model and thus have no influence on the results. However, including these will provide this research with valuable information. Firstly, the overall satisfaction of the transport abilities is included. The overall satisfaction is not part of the conceptualization in chapter 2, and thus cannot be assigned to one of the three indicator categories on theoretical grounds. However, the satisfaction indicators satisfy another objective as specified in section 3.1. The results from satisfaction indicators will be combined with the results from the ODiN integration to provide a detailed indication of the past transport problems. It is therefore essential to include these two satisfaction indicators in the LCA model as inactive covariates. Secondly, the indicators which construct the factors

‘mobility health hinderance’ and ‘forced car ownership’ are also included as inactive covariates. As explained in 3.4.1, the underlying indicators of these factors are highly correlated with each other, which would result in a misrepresentation of the data. Hence, the constructed factor scores allow for the inclusion of ‘mobility health hinderance’ and ‘forced car ownership’ in the construction of the groups. However, the factor scores are difficult to interpret, they only indicate the direction of the value: lower than the average (negative) or higher than the average (positive). The inclusion of the underlying indicators as inactive covariates will allow for easier interpretation of these factors. Table 11 presents the inactive covariates included in the LCA model.

Table 11: inactive covariates in the LCA model.

Conceptualization reference	Inactive covariates
Transport satisfaction	I can easily carry out my desired daily activities
	All in all, I am satisfied with how I can get around
Forced car ownership	Actually, I can hardly afford the cost of car use
	Car ownership is a necessity, not a free choice
Mobility health hinderance	To what extent does your health hinder you from walking?
	To what extent does your health hinder you from cycling?
	To what extent does your health hinder you from driving?
	To what extent does your health hinder you when travelling with PT?

4.3.3 Model estimation

To identify the optimal number of classes and asses the model fit, LCA allows for the utilization of statistical criteria. This research will use the Bayesian Information Criterion (BIC) as the main criteria. However, the Akaike Information Criterion (AIC) and the Log-Likelihood (LL) are also calculated to assess model fit for each of the models. The program of Latent Gold allows for including missing values to maximize the number of individuals included in the model. This is a very important feature in case of the affordability indicators. Not every individual has conducted the additional affordability survey which would have resulted in a much smaller number of individuals and possibly an inferior model. The selection of the best model and thus the model with the optimal number of groups is an iterative process. The LCA method requires the estimation of every model until the optimum is achieved. Starting with the first model which has one cluster, there is one groups added to the previous model at each step.

After conducting this iterative process, the model with eleven groups is the optimal model. The table below presents the values of the criteria of each model. The BIC value continues to decrease until the twelfth model, where it rises. The significance of the indicators and covariates is tested with the Wald-statistic and the associating probability value. If the probability value is larger than 0.05, the indicator or covariate is not significant and cannot be translated to the population. Therefore, no real conclusions can

be made about the values of the indicator or covariate. In model eleven, all indicators are statistically significant with values lower than 0.05, thus can be translated to the population. However, in the covariates, 'origin of person' is found to be statistical insignificant with a probability value larger than 0,05. This means that when the models control for the other covariates, the origin of the person has no unique effect on the latent groups. This is understandable regarding the sample of the MPN in which the vast majority is of Dutch origin.
The entropy R-squared was also used to assess the effectiveness of the model. This value explains the extent to what the model accurately places the individuals in the correct groups. The entropy R-squared value is 0.93 for this model and is significantly larger than the desired 0.80 minimum. The R-squared values of the indicators are also interesting to assess for the extent to which each indicator explain the different groups. The R-squared values of the urbanity, the distances to public transport and essential activities and car ownership have the highest values of the indicators.

Table 12: Latent Gold model fit output

	#Groups	**LL**	**BIC(LL)**	**AIC(LL)**
Model1	1-Cluster	-281765.6123	564166.7676	563683.2245
Model2	2-Cluster	-266393.3740	534233.4447	533132.7479
Model3	3-Cluster	-260483.9927	523225.8358	521507.9854
Model4	4-Cluster	-257139.9101	517348.8243	515013.8202
Model5	5-Cluster	-255620.1276	515120.4129	512168.2551
Model6	6-Cluster	-253067.4723	510826.2561	507256.9447
Model7	7-Cluster	-251823.8061	509150.0774	504963.6123
Model8	8-Cluster	-250807.2798	507928.1783	503124.5595
Model9	9-Cluster	-250146.7417	507418.2559	501997.4835
Model10	10-Cluster	-249344.8146	506625.5552	500587.6291
Model11	11-Cluster	-248459.3414	505665.7627	499010.6829
Model 12	12-Cluster	-248335.6645	506229.5625	498957.3290

5. Results

The fifth chapter of this research presents the results of the LCA model. In the first part, the raw results from the model are presented in two tables. The groups are also presented with associating labels. In the second part, the results from the ODiN integration and the inclusion of the MPN mobility satisfaction levels are specified. The chapter continues with the visualization, discussion and analysis for every group.

5.1 Results overview

Table 13 present the results of the LCA model. The model includes a high number of indicators, so only the available means for every indicator is includes in the table. The complete output table is put in the appendix. It is important to understand the directions of the scales and factors in order to prevent misinterpretation of the results. The urbanity scale is formulated so that a low value means a higher urbanity and thus a higher population density in the area of residence of the individual. A negative value on the 'forced car ownership' indicators means that the individual experiences the phenomenon of forced car ownership less than average. A negative value on the 'mobility health hinderance' indicator means that the individual does experience more mobility hinderance due to their health.

After analyzing the results, this research is able to construct fitting labels to efficiently refer to the different groups and to express the most notable characteristics of the groups. The labels will be formulated combining both the results from the indicators and the covariates.

- *Cluster 1: High income suburban residents with high accessibility and high car use*
- *Cluster 2: High income urban residents with high accessibility and high car use*
- *Cluster 3: Older suburban residents with further away train station and hospital*
- *Cluster 4: Older urban car owners with high accessibility*
- *Cluster 5: High income moderate rural car users with low accessibility*
- *Cluster 6: Older suburban car owners with lower employment accessibility*
- *Cluster 7: Older moderate rural car users with high car accessibility*
- *Cluster 8: Urban residents with no car and high accessibility*
- *Cluster 9: Older rural car owners with lower PT accessibility and PT affordability*
- *Cluster 10: Rural car owners with extremely low accessibility*
- *Cluster 11: Young suburban bicycle and public transport users*

Table 13: LCA indicator results.

Indicators	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster10	Cluster11
Cluster Size (%)	17.54	16.72	9.73	9.52	9.02	8.58	8.24	7.64	5.03	4.74	3.24
Overall mobility affordability (scale)											
Mean	1.92	1.83	2.35	2.02	1.86	2.04	2.06	2.20	2.39	2.40	2.33
PT affordability (scale)											
Mean	2.06	1.78	2.65	2.18	2.01	2.05	2.38	2.30	3.00	2.67	2.36
Forced car ownership factor											
Mean	-0.08	-0.29	0.39	0.03	-0.30	-0.03	0.05	0.93	0.49	0.44	0.98
Urbanity (scale)											
Mean	2.86	1.58	2.66	1.42	3.74	2.23	3.70	1.39	3.67	4.21	2.85
Distance highway (m)											
Mean	3059.65	2155.76	3466.46	2192.07	7025.53	1677.21	3755.72	2017.72	9907.45	10430.20	3815.18
Distance train station (m)											
Mean	3715.16	1855.19	5088.48	2032.34	6072.61	1649.48	4584.71	1401.86	7978.49	6947.16	3247.71
Distance bus stop 4xpu (m)											
Mean	927.89	351.72	514.97	268.66	3517.21	1083.74	2759.95	329.24	795.18	6543.79	1500.16
Distance bus stop 1xpu (m)											
Mean	316.17	217.99	268.74	215.89	470.37	365.84	442.41	225.65	352.62	1158.17	419.34
Number of jobs 50km											
Mean	1441.08	1725.77	1488.43	1730.87	691.95	1284.71	1383.20	1839.03	554.55	526.82	1327.64
Distance general practitioner (km)											
Mean	1.25	0.82	1.10	0.82	2.03	1.22	1.79	0.79	1.34	2.98	1.23
Distance hospital (km)											
Mean	7.91	3.30	7.42	3.35	12.03	4.60	10.78	2.75	12.27	14.69	7.84
Distance supermarket (km)											
Mean	1.15	0.75	0.96	0.76	1.80	1.10	1.73	0.69	1.14	2.47	1.19
Car ownership											
No	0.03	0.11	0.26	0.04	0.05	0.10	0.08	0.86	0.09	0.14	0.76
Yes	0.97	0.88	0.68	0.96	0.95	0.90	0.89	0.01	0.88	0.83	0.20
Person does not own any mode of transport	0.00	0.01	0.05	0.00	0.00	0.00	0.03	0.13	0.03	0.04	0.04

Car km as driver (scale)											
Mean	4.27	3.98	3.27	3.53	4.58	3.57	3.80	1.44	3.39	3.89	2.08
Car availability											
Yes. whenever I want	0.78	0.70	0.57	0.77	0.81	0.71	0.70	0.01	0.71	0.72	0.11
No. I have to coordinate that with my household	0.18	0.23	0.13	0.16	0.16	0.20	0.19	0.03	0.15	0.13	0.28
No. but I can sometimes use a friend's car	0.01	0.03	0.02	0.01	0.01	0.01	0.01	0.16	0.02	0.01	0.16
No. (almost) never	0.01	0.01	0.05	0.02	0.00	0.01	0.02	0.20	0.05	0.02	0.07
Person does not have a car license	0.02	0.04	0.23	0.04	0.02	0.08	0.08	0.60	0.08	0.12	0.38
Bicycle ownership											
No	0.16	0.18	0.32	0.27	0.17	0.16	0.20	0.21	0.23	0.32	0.11
Yes	0.84	0.82	0.68	0.73	0.83	0.84	0.80	0.79	0.77	0.68	0.89
Car use (scale)											
Mean	1.66	1.94	2.45	1.92	1.46	2.02	1.98	4.30	2.04	1.95	3.12
Train use (scale)											
Mean	5.24	4.75	5.53	5.37	5.37	5.18	5.55	3.95	5.74	5.51	2.49
BTM use (scale)											
Mean	5.30	4.75	5.23	4.99	5.55	5.23	5.62	3.62	5.68	5.55	3.06
Bicycle use (scale)											
Mean	3.55	3.17	4.81	4.43	3.54	3.90	4.56	3.27	3.94	4.58	1.73
Ebike use (scale)											
Mean	4.36	4.66	4.18	4.21	4.45	4.02	4.04	4.95	4.16	4.26	5.48
Walking use (scale)											
Mean	1.93	1.83	2.44	2.21	2.18	1.94	2.38	1.88	2.27	2.37	1.52
Mobility health hinderance factor											
Mean	0.64	0.64	-0.87	-0.57	0.64	-0.34	-0.62	-0.39	-0.49	-0.34	0.41

Table 14 presents the results of the covariates from the LCA model. Figure 7 presents the dominant cluster per four-digit zip code. The geographical distribution of individuals for every cluster is put in the appendix. The grey areas in figure 7 are not represented in the MPN dataset.

Table 14: LCA covariates results.

Covariates	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11
Cluster Size (%)	17.54	16.72	9.73	9.52	9.02	8.58	8.24	7.64	5.03	4.74	3.24
Gender											
Man	0.52	0.53	0.35	0.47	0.53	0.43	0.42	0.36	0.48	0.44	0.38
Woman	0.48	0.47	0.65	0.53	0.47	0.57	0.58	0.64	0.52	0.56	0.62
Age											
Mean	48.64	47.43	60.47	57.74	48.11	56.70	57.57	50.25	57.24	53.81	29.56
Migration background											
Dutch native	0.91	0.89	0.93	0.89	0.94	0.92	0.95	0.87	0.93	0.95	0.88
(Other) Europe	0.03	0.03	0.03	0.04	0.03	0.04	0.02	0.06	0.03	0.02	0.06
Other world (not Europe)	0.03	0.05	0.02	0.05	0.01	0.02	0.01	0.05	0.03	0.01	0.05
Unknown	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.00	0.02	0.01
Household size											
Mean	2.71	2.44	2.09	2.04	2.78	2.26	2.41	1.62	2.31	2.48	2.93
Household income											
Mean	17.18	17.27	15.21	15.50	17.84	16.37	16.27	14.07	15.92	16.77	16.25
Education level											
Basic education	0.02	0.03	0.05	0.03	0.04	0.02	0.03	0.07	0.05	0.07	0.17
Lower education	0.08	0.07	0.18	0.13	0.09	0.16	0.15	0.11	0.23	0.15	0.05
MAVO. lower HAVO. VWO	0.07	0.08	0.17	0.15	0.07	0.09	0.11	0.14	0.11	0.15	0.14
MBO. HAVO. VWO	0.39	0.35	0.39	0.38	0.41	0.38	0.40	0.34	0.38	0.49	0.46
HBO. WO	0.43	0.47	0.21	0.31	0.40	0.35	0.31	0.34	0.23	0.15	0.18
Unknown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Employment status											
Paid employment	0.78	0.73	0.26	0.44	0.76	0.48	0.44	0.37	0.39	0.47	0.46
Incapacitated for work	0.00	0.01	0.13	0.08	0.01	0.08	0.11	0.11	0.13	0.12	0.01
Unemployed	0.00	0.01	0.04	0.01	0.00	0.02	0.01	0.05	0.02	0.02	0.05
Retired or early retirement	0.15	0.16	0.37	0.38	0.15	0.34	0.30	0.28	0.32	0.23	0.04
Student	0.02	0.04	0.01	0.00	0.03	0.00	0.01	0.12	0.02	0.03	0.42
Housewife/househusband	0.04	0.03	0.13	0.06	0.03	0.05	0.09	0.03	0.07	0.09	0.01
Volunteering	0.01	0.01	0.04	0.03	0.02	0.02	0.03	0.03	0.04	0.02	0.01
Unknown	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Other	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01

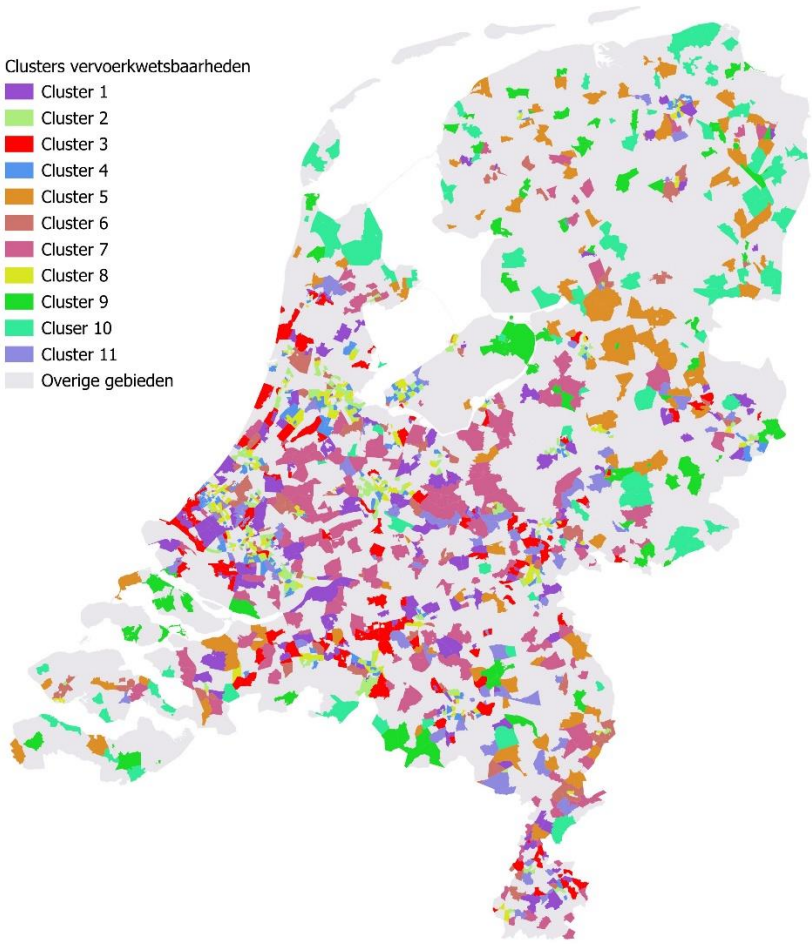

Figure 7: dominant cluster per four-digit zip code.

5.2 ODiN integration

Table 15 presents the cluster sizes in the ODiN integration. Noteworthy is the higher percentage of cluster two and the lower percentage of group eight.

Table 15: ODiN cluster sizes.

ODiN	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Cluster9	Cluster10	Cluster11
Cluster Size (%)	22,2	30,4	10,6	7,1	6	6,9	7,1	1,9	3,7	3,6	0,4

The results of the ODiN dataset are for the most part in line with the results of the LCA. Figure 8 present the relative values of the inaccessibility of different activities. This means that the values of the group are compared with the average value of all the groups. The figure with the actual values is put in the appendix.

Group three has a relatively high percentage of respondents that indicate to have had problems accessing all essential locations. The LCA with the MPN data shows that individuals in group three live in suburban areas but live relatively far away from the nearest train station and are more car dependent but not always own a car. Groups one, two and five experience minimal transportation problems according to the ODiN data. The LCA reveals that these groups have high incomes, own a car and have high transportation affordability. This explains the low values resulting from the ODiN data. Group eight has a relatively high percentages of individuals who have had problems accessing essential destination, especially work and school. The LCA shows that the individuals in this group do not own a car, often live alone and thus have low household income. These factors are presumably the reason for the higher inaccessibility percentages. Especially when work is not easily accessible by public transport.

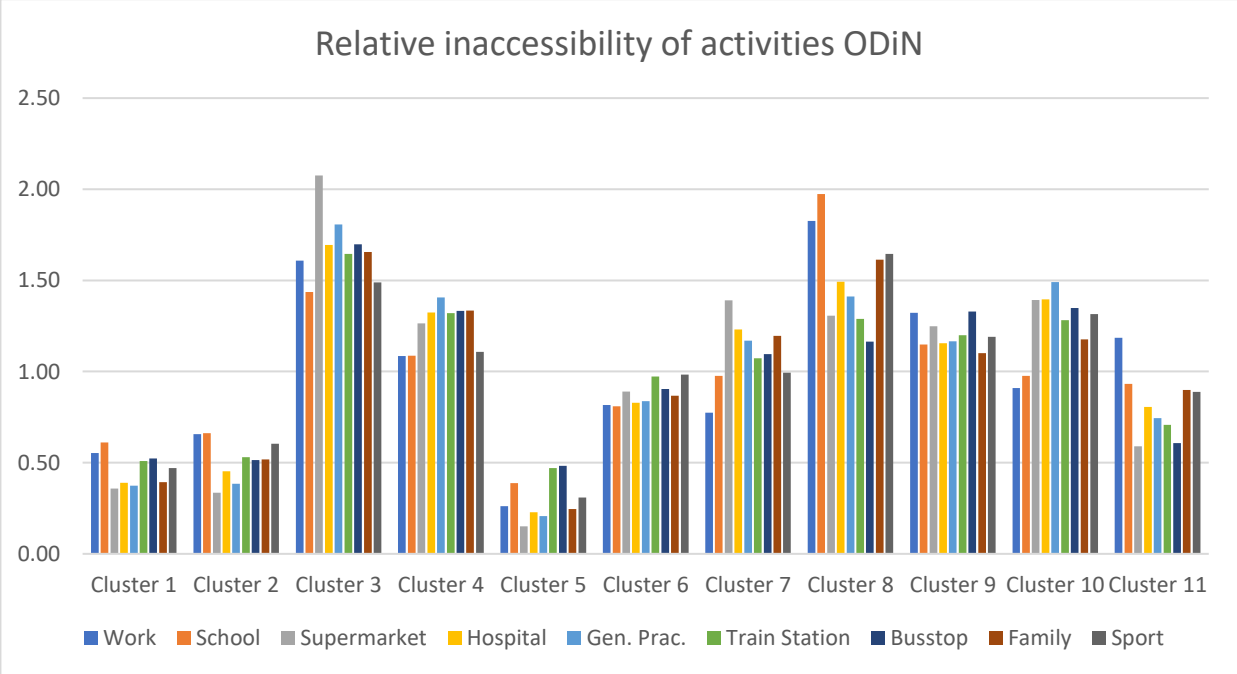

Figure 8: relative inaccessibility of activities ODiN.

5.3 MPN mobility (dis)satisfaction levels

The other aspect in establishing statistical evidence whether a group has experienced past transport problems is the utilization of the satisfactory questions of the MPN. It should be noted that the initial results show that the average satisfaction of individuals in all groups is positive. This means that in each group there is a high percentage of individuals who are satisfied with their overall transportation and the ability to conduct their daily activities. In order to compare the dissatisfaction per group, the percentage of individuals in each group who were dissatisfied are specified. Figure 9 presents the relative amounts of the two satisfaction question in the MPN survey. It is clear that there the pattern between the groups for the most part corresponds with the pattern of the results of the LCA results and the ODiN integration. Groups one, two and five contain almost no individuals who are dissatisfied. Group three, which is the group with the most transport vulnerabilities, surprisingly has a low percentage of individuals who are dissatisfied with their mobility. On the hand, group eight has by far the highest percentage of individuals who are dissatisfied. This is also somewhat surprising regarding the high accessibility of essential activities and public transport. The high percentage is presumable the case because of the non-existing car ownership in this groups. Lastly, the satisfaction of group ten is also interesting and noteworthy. This group has the lowest accessibility and relatively low affordability. However, the percentage of individuals who are dissatisfied with their mobility is among the lowest of all groups.

The satisfaction questions do not specify whether the individual was actual able to access their desired destinations. An individuals can be dissatisfied with their transportation but can still access their essential activities. The inaccessibility questions directly show if the activity was in fact inaccessible. This can explain the difference between the number of individuals who are dissatisfied and who experienced inaccessibility in groups seven, nine, ten and eleven. If a group is relatively more dissatisfied but is still able to access their desired activities, could indicate a higher future transport vulnerability. This is true for groups nine and eleven.

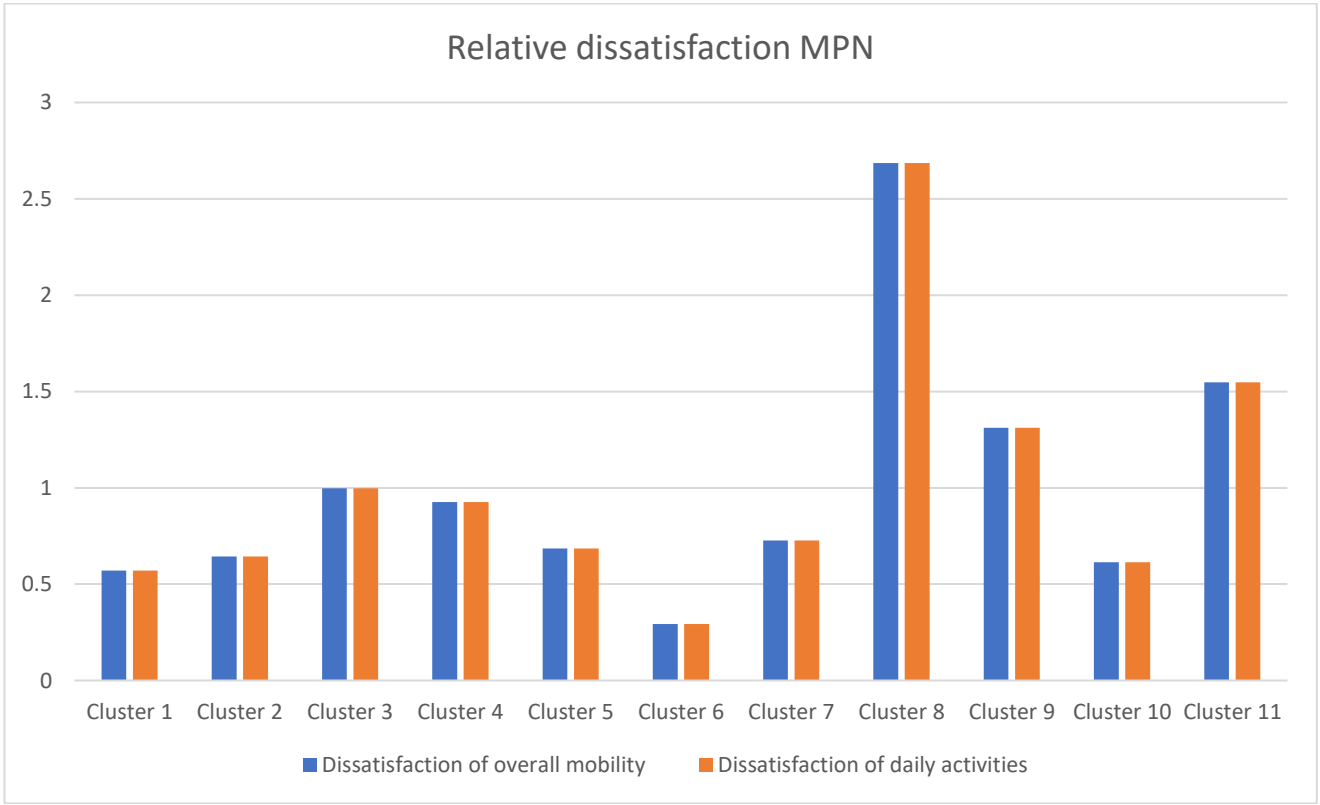

Figure 9: relative dissatisfaction MPN.

5.4 Discussion of the groups

In this section the eleven groups will be presented with descriptions and visualization. The potential transport vulnerabilities for every group will also be determined. It is important to refer back to the conceptual model of transport poverty risk constructed by this research. Generally, a group of people is deemed to be at risk of transport problems if the group is vulnerable in at least two of the three categories of accessibility, mobility or affordability. However, it is required to evaluate each group individually and reflect on the specific potential reasons why that group might have higher risk of transport problems. The personal attributes contribute to the transport needs and capabilities of the individual and the group. In order to analyze the transport disparities in the Netherlands and to determine to what extent transport inequality is present between the groups, this research will analyze the groups using values relative to the mean of every indicator. This means that the values in table 13 will be converted to a value relative to the mean of that associating indicator. This could for example result in the following statement: "group four has relatively low distances to the public transport network when compared to the other groups". The figures with all relative values per transport poverty risk aspect are put in the appendix. Figures 10 and 11 presents the overview of the groups using a simple visualization of every group.

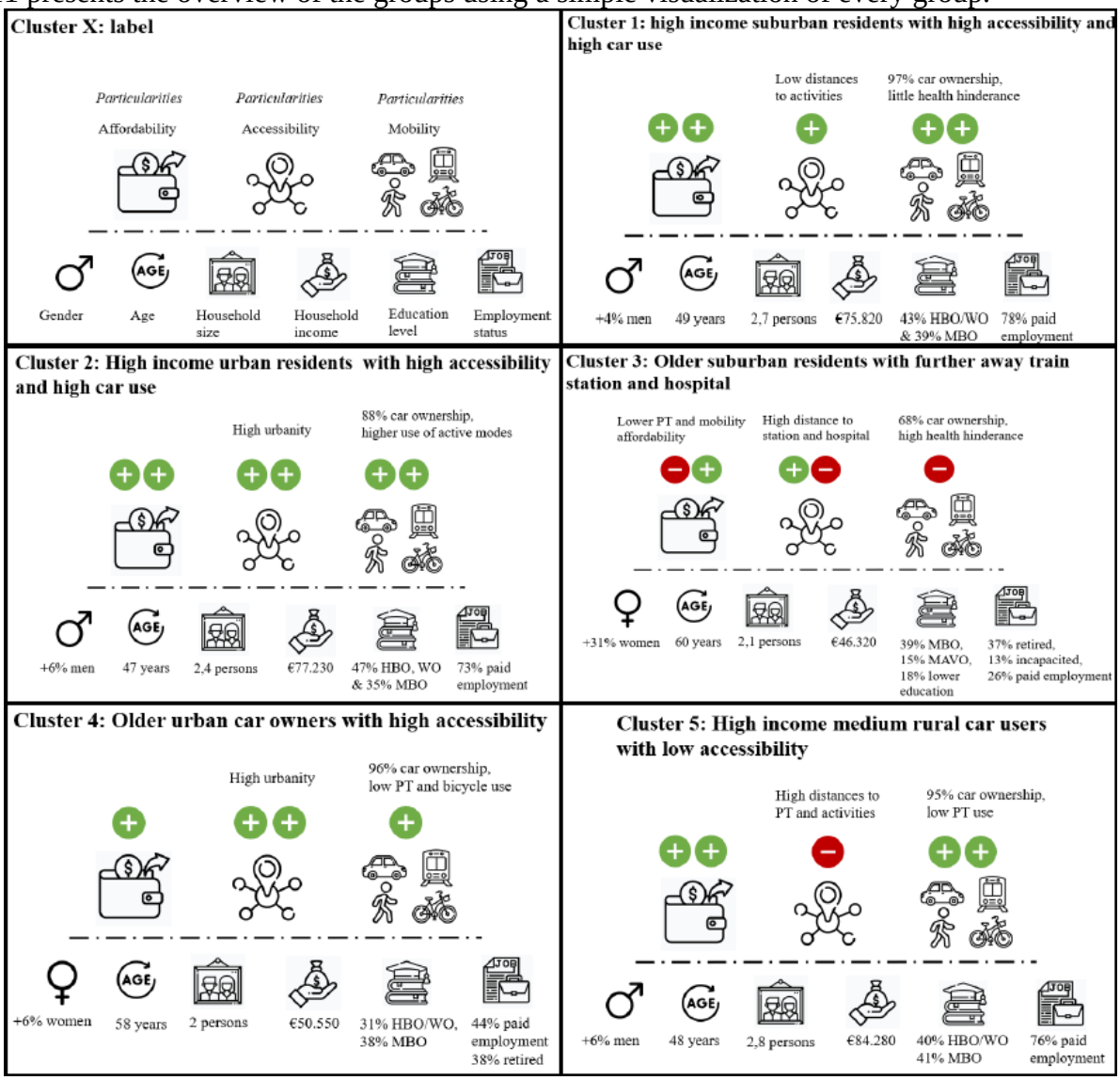

Figure 10: visualization of the clusters (part 1/2).

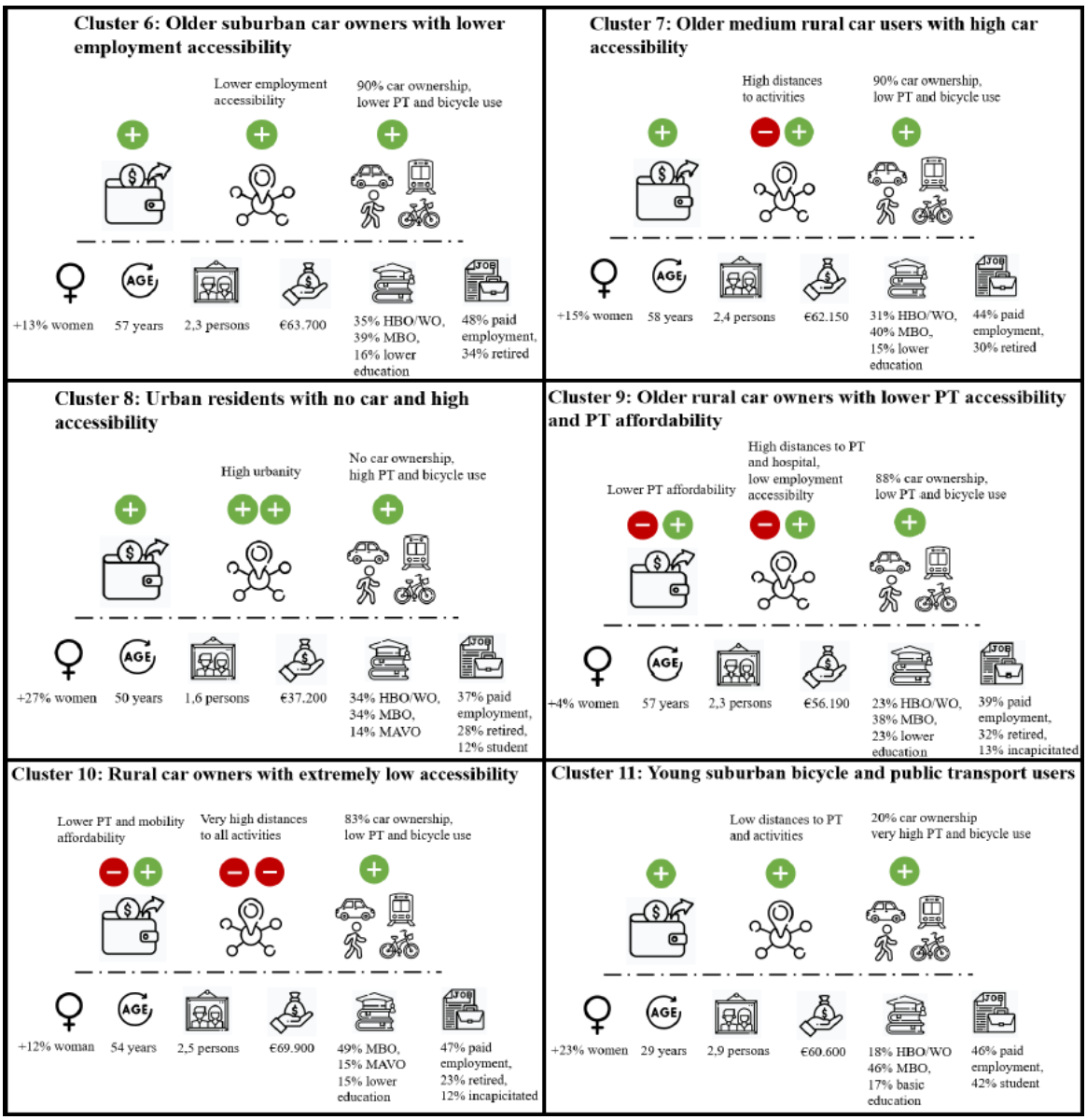

Figure 11: visualization of the clusters (part 2/2).

Cluster 1: High income suburban residents with high accessibility and high car use

The first group is the largest of the population. They live in suburban areas. Due to the high household income, the affordability of this group is high. Car ownership is also very high, so is car use and the number of kilometers travelled in a car. This means that these individuals have the financial freedom to purchase a car and also use it more often, likely because of the suburban residence area and the high employment percentage. They also have access to the public transport network as the distances to the train station and bus stop are below average. However, the use of public transport is relatively low, presumably because of the high car ownership. Another explanation could be that the higher bicycle ownership and use is also high. The distances to the different destinations are relatively low so the bicycle can be an attractive alternative to the car, especially when there is little experience of mobility hinderance due to the health issues. It is clear that there is no evidence that this group has any transport vulnerabilities and therefore any risk on transport problems. It scores high on every aspect of transport poverty risk. This group is therefore deemed as being relatively 'rich' with high affordability, high accessibility and high mobility.

Cluster 2: High income urban residents with high accessibility and high car use

The second group represents individuals who live in high urban areas and can also easily afford their transportations. This can also be determined by high amount of household income. The urban environment means high public transit and activity accessibility. This is likely the reason for the higher public transit and bicycle use than in group one. Still, car ownership is high even with the high urbanity area. However, car use is lower than in the previous group and the use of active modes and public transport has therefore increased with low experience of any mobility hinderances due to health. The majority of the individuals has paid employment and presumably does not need to travel far for that employment as the employment accessibility is very high. The second group is comparable with the first group as being relatively transport 'rich' with having high affordability, high accessibility and high mobility. This group has no transport vulnerability or substantial risk of transport problems.

Cluster 3: Older suburban residents with further away train station and hospital

The individuals in the third group are residents of suburban areas. Their affordability of mobility and public transit is one of the lowest compared to the other groups and the forced car ownership factor is also higher. Interestingly, the train station is relatively far away despite their urbanity level. The bus stop is however close by and could compensate for the large distance to the train station. This could be an explanation on the relatively low transport affordability. The distances to the activities are however very low making the accessibility of this group high, including employment accessibility. The mobility level of this group is also interesting. Car ownership and use is below average. Additionally, the ownership and use of the active modes are also relatively low with bicycle use being the lowest of all groups. The mobility health hinderance is presumable the reason for this mobility level. The individuals have relatively high health hinderances for every modality. This can be explained when regarding the older age of this group, 60. When including the ODiN integration and the MPN satisfaction levels, this group includes a high percentage of individuals who have experienced problems accessing their essential activities and who are not satisfied with their transportation. It is clear that this group includes individuals who are not able to use modalities in order to access the desired destinations and are therefore vulnerable regarding their mobility level. They are also vulnerable in the affordability aspect with their household income being lower than the majority of other groups. This combination makes them more prone to transport problems when compared the rest. The lower distances to activities could relieve them of some risk, however when use of active modalities is not possible due to their health and age, these lower distances cannot compensate for the other vulnerabilities.

Cluster 4: Older urban car owners with high accessibility

The fourth group includes individuals who are residents in the city areas. This means very high public transit and activity accessibility. Affordability of mobility is high with little experience of forced car ownership. Car ownership is one of the highest of all groups. The ownership and use of the active travel modes and public transport is relatively low. This makes sense when regarding the also higher car use. This is however interesting when looking at the high urbanity. This means that these individuals actively choose to use the car in state of other modes even though they are highly accessible and an effective alternative. The ODiN integration and MPN satisfaction levels reveal a slightly lower accessibility and satisfaction compared to the other groups. Especially regarding the daily activities. An explanation could be the car congestion in the cities and the anti-car policies in the city centers. When analyzing the levels of the three aspects, affordability, accessibility and mobility levels are all relatively high. This means that there is no substantial evidence that this group is transport vulnerable or has higher risk of experiencing transport problems.

Cluster 5: High income moderate rural car users with low accessibility

The fifth group includes individuals who live in more rural areas. They have the highest amount of household income of all the groups. The transport affordability is therefore also high. This could indicate that they chose to live in these more rural areas as they can easily afford the higher transportation costs. This is because due to the rural area, the distances to the essential activities are very high compared to the other groups. This is compensated with the very high car ownership and especially high car use. Distances to the public transport network are also very large, partly explaining the low use of public transport. The fifth group is similar to the first two in the amount of transport problem risk, which is minimal. This group is however vulnerable in one aspect, accessibility. This vulnerability is compensated by the high income and affordability and high mobility level.

Cluster 6: Older suburban car owners with lower employment accessibility

Group six includes individuals who live in relatively urban areas. They can financially afford their mobility needs and public transport use and also experience little forced car ownership, meaning they do not need to compensate car ownership in other needs in their lives. Their public transport accessibility is relatively high, and the distances to essential destinations are also very low. However, the employment accessibility is lower than expected. This is quite interesting when looking at the urbanity and other accessibilities. This can explain the relatively high car ownership. However, car use is around average which is also lower than expected. The same is true for the public transport and the active travel modes. The sixth group includes individuals who are not directly vulnerable to transport problems. Affordability, accessibility and mobility are all adequate for this group. More than half of the individuals of this group do not need to access employment due to retirement or inability to work. This shows the importance of including the individuals transport needs when analyzing transport poverty risk. The relatively low employment accessibility can be interpreted as a vulnerability, however this is partly negated when including the high share of retirement. This can also explain the lower use of overall transportation as the amount of transportation needs are expected to be lower for this group. The affordability and the other accessibilities are all high, resulting in a low risk of transport problems.

Cluster 7: Older moderate rural car users with high car accessibility

Individuals in this group are residents of more rural areas. The essential destinations such as hospital and supermarket are therefore further away. The public transit accessibility is also lower compared to the other groups. The affordability of this group is around average with the household income also being average compared to the rest. When analyzing the mobility, car ownership is relatively high which makes sense regarding the higher distances. In comparison, the use of all other modes is lower than average. The flexibility of car ownership could explain this. Also interesting, employment accessibility is relatively high when regarding the urbanity level. This means that the majority of this group which has paid employment does not need to travel very far to access their employment. This group is another case in which the car as a transportation modality seems to compensate for the larger distances. This means that this group is vulnerable when looking at the accessibility levels, however this is compensated by the higher affordability and high mobility levels. When including the ODiN integration, this group does have relatively high percentages of individuals who indicate to have experienced problems accessing essential activities. However, the satisfaction levels are average compared to the other groups, indicating that the inaccessibility of those activities does not necessarily affect the satisfaction.

Cluster 8: Urban residents with no car and high accessibility

This group includes individuals who live in high urban areas. This means that their accessibility to the public transport network and to the essential activities is extremely high, including employment accessibility. What makes this group noteworthy is the amount car ownership. Car ownership is minimal

at one percent and half of the individuals does not have driver's license. The use of the other modalities in public transport, bicycle and walking is therefore higher for this group. Household income is the lowest of all groups, which is logical when regarding that these individuals are more often living alone. It is however interesting then that the affordability levels are relatively average. The three aspects of affordability, accessibility and mobility are all high for this group. Even though these individuals do not own a car, they are able to use the other modalities to access the essential destinations. However, larger distances to destination they cannot choose are a possible issue. This becomes apparent when including the ODiN integration and the MPN satisfaction levels. This group has the highest percentage of individuals who have experienced problems to access their family and the hospital. These are destinations they cannot control or choose. The ODiN integration also reveals a relatively high percentage of individuals who have had problems accessing work and school and work, which is very interesting regarding the urbanity of the residence area. It also noteworthy that despite the high values of affordability, accessibility and to a lesser extent mobility, the satisfaction are amongst lowest values of al groups, this is true for both the overall mobility and the daily activities. This shows the uncertainty between the levels of someone's transportation opportunities and the actual ability and satisfaction of accessing essential activities.

Cluster 9: Older rural car owners with lower PT accessibility and PT affordability

This group includes individuals who live in rural areas. The distance to the highway, train station and the hospital are relatively high. The access points of the using the car and train modalities for larger distances are therefore relatively inaccessible. This becomes an issue when looking at the low employment accessibility, which means that the individuals who have paid employment presumably need to travel a larger distance at a more frequent basis. The low car and train accessibility emphasizes the need to position the essential activities near these rural areas. The affordability of the transportation is also relatively low compared to the other groups. Especially the public transport affordability, which is the lowest of al groups. This means that there is a double barrier of the use of public transport, it is inaccessible and not affordable. The larger distances to essential locations, often involving transfers, could explain this affordability barrier. The value of the forced car ownership factor is also the highest of all groups. This means that the individuals have more trouble affording their car use and view the car as a necessity when compared to the other groups. As expected, car ownership is high in this group and the use of the other modes is low. Interestingly the number of km driven in a car is relatively average. This is surprising regarding the high distances to the activities and the car dependency. The ODiN integration does not reveal a high percentage of individuals who have experienced transport problems. There is only a relatively high percentage for the accessibility of the public transport network. The percentage of individuals who are dissatisfaction with their overall mobility and the completion of their daily activities is relatively high. This could indicate that although these individuals are able to access the essential destinations, presumably because car ownership is still high, the high distances do negatively influence their satisfaction levels.

Cluster 10: Rural car owners with extremely low accessibility

This group includes individuals who live in rural areas. This results in the lowest car and public transport accessibility. The difference with group nine is that besides the inaccessibility of the highway and train station is that the distances to other essential activities such as general practitioner and the supermarket are also very large. Employment accessibility is still extremely low compared to the other groups. When analyzing the accessibility levels, it is clear that these individuals live relatively isolated. This could also explain the affordability which is below average. Additionally, there is a higher-than-average experience of forced car ownership. Car ownership is relatively high but interestingly not as high as expected. It is lower than that of group nine while having even larger distances. Bicycle ownership and the use of public transport are relatively low as expected. The inclusion of the ODiN integration and the MPN satisfaction

levels reveals several interesting insides. The ODiN does not reveal significantly high percentages of inaccessibility of essential activities. Only the accessibility of the hospital and public transport network have relatively high values. Even more noteworthy are the satisfaction levels. This group has relatively high satisfaction levels which is not expected with such high distances. The high household income could be an explanation, which is comparable to groups one and two. This could indicate that a higher income could negate other transport vulnerabilities.

Cluster 11: Young suburban bicycle and public transport users

The last group includes individuals who live in suburban areas. The distances to the public transport network, essential activities and employments accessibility are all average when compared to the other groups. This is also true for the relative affordability of this groups. The noteworthy part of group eleven is the extremely low car ownership. A large part of the individuals does not even have a driver's license. On the other hand, the use of public transport, the bicycle and walking are the highest of all the groups. Another noteworthy element of this group is that the average age of this group is by far the lowest of all groups with a high percentage being either a student or having paid employment. Household size is also the highest of all groups with the household income also being very high when regarding the number of students. Together with the fact that these individuals live in suburban areas, even though they are often student, indicates that many are still living with their parents. The ODiN integration reveal low percentages of individuals who experienced transport problems. Interestingly, there is also a low percentage of individuals who experienced problems accessing their schools. The MPN satisfaction are however below average with their being a higher percentage of individuals who are not satisfied with their overall mobility. All in all, this group has high values in all three aspects of affordability, accessibility and mobility and thus have a relatively low risk of experiencing transport problems.

5.4.1 Transport vulnerabilities

The Latent Cluster Analysis reveals five groups that have transport vulnerabilities. The conceptual model of transport poverty risk is used to indicate whether these transport vulnerabilities actually translate to transport problems. The conceptual model argues that in order to have substantial risk of transport problems, an individual needs to be vulnerable in at least two of the three categories of factors (affordability, accessibility and mobility). If an individual is only vulnerable in one of these categories, that vulnerability can be compensated by higher levels on the other two categories.

This last part is true for groups five, seven, nine and ten. Groups five and seven experience lower accessibility due to higher distances to essential locations and public transport. However, their relatively high values of affordability and mobility compensate for the lower accessibility. This is especially true for group five which has the highest household income of all groups. So, these groups can use their car to travel the longer distances and can also afford to pay the extra costs. In addition to experiencing the lowest accessibility, groups nine and ten also experience relatively low affordability. This could meet the condition that these groups experience vulnerabilities in at least two of the three categories. However, when looking at the absolute affordability values, not relative to the mean of all groups, these values are still positive as no group indicated to be unable to afford their daily mobility. Thus, these groups are not labelled as having transport problems to essential locations.

There is one group that does meet the condition, group three. This group experiences vulnerability in all three categories. But as stated the affordability vulnerability is relative to the other groups and is not a substantial vulnerability in absolute term. However, the household income is lower than the rest of the groups when regarding the household size. This can indicate a real future vulnerability. The accessibility of group three is lower due to higher distances to the train station and hospital. What makes this group interesting is the mobility vulnerability. The higher health hinderance of cycling and walking and the

higher distance to the train station, indicates that this group is more car dependent. However, the car ownership is far below the average. So, this group is less capable of compensating for the lower accessibility level. Thus, group three can be labelled as having substantial risk of transport problems to essential locations.

6. Policy analysis

The sixth chapter of this research represents the policy relevance. The consultation with the policymakers is used for the identification of additional transport vulnerabilities and for feedback on the results. The second part of this chapter uses the latent groups as a thought experiment to indicate the effect of future policies on the groups and thus the transport inequality. In light of the ongoing government formation process, the mobility policy packages of three different political parties in regard to car, road and public transport are applied.

6.1 Policymaker consultation

6.1.1 Identification of transport vulnerabilities

The policymakers identified three potential vulnerabilities according to the different groups. The first vulnerability is associated with groups that include individuals who are older in age and are more dependent on the car as a transportation mode. This can result in future vulnerability as car use becomes more difficult with increasing age. This also often means the inability to use active travel modes to access activities. In that case, public transport access and reliability becomes more important for these individuals. The individuals in groups four, six, seven and nine are all older in age and are presumably more car dependent with car ownership and use being relatively high. The extent of the vulnerability mostly depends on the household income and the distances to the essential activities. Group three already experiences this vulnerability. Car ownership has decreased to below average, and a relatively high percentage of individuals indicate to experience hinderance in mobility due to their health. This means that the use of other modalities than the car is very low. The lower household income of group three magnifies the vulnerability resulting from the higher age and car dependency.

The second vulnerability is associated with the social safety net of the individual. Meaning to what extent can the individual rely on their social environment to compensate for any transport problems. Group eight includes individuals who more often live alone. This means that they cannot rely on the mobility of the rest of the household. This especially becomes problematic when something occurs which affects their physical or mental capacity to travel. Another aspect of the social safety net vulnerability applies to two person households who are older in age, with the individual being a woman. It is a known phenomenon that the partner of this individual is no longer capable of assisting in their mobility needs either due to passing of the partner of deteriorating health. The dependency on their partner causes the individual to experience transport problems. The individuals in group three are especially associated with this vulnerability. They are higher in age, have lower car ownership, higher health hinderance and are more often a woman. Household size is also two persons on average.

The third identified vulnerability by the policymakers is associated with the residence area of the individual. Most locations of essential activities can be chosen, for example to go to the closer supermarket by bike or travel to the further supermarket by car. This depends on personal preferences. However, the locations of social contacts like family and friends cannot be chosen. Social contacts are also an essential destination as isolation can cause loneliness and a decreased well-being. It becomes problematic when these social contacts live further away, and the individuals has no mobility capacity to easily access these locations. This is true for group eight, for which individuals do not own a car. This results they are vulnerable for longer distances. The inability to access social contacts who live further away, also works the other way around. If an individual lives in a rural area, it becomes more difficult for their social contact to reach them. This is especially true for older individuals who live in rural areas. For example, they are dependent on the mobility capacity of their family and friends to reach them. This

can also result in social isolation, loneliness and lower well-being. This is true for groups seven, nine and ten.

6.1.2 Identification of missing elements

The second part of the consultation was dedicated to reflecting on the validity of the groups. The policymakers reported several societal groups which are missing from the results. The issue is not directly that the model did not capture the groups, but it can also mean that the MPN and ODiN surveys do not provide (sufficient) data on these aspects. It is also important to note that these surveys are done at national level. When applying the statistical model to the whole country of the Netherlands, it is unlikely for the model to identify these specific but more importantly very small groups. This becomes impossible if the dataset does not include any individuals from those groups. It is apparent to acknowledge to limitations of both the statistical model and the surveys in the analysis of the transport vulnerabilities and transport inequality. Not doing so, would result in a misinterpretation of the national issue.

The first underrepresented group according to the policymakers are the non-Dutch citizens. These individuals may not be able to understand the Dutch language which makes them more vulnerable in the Dutch transport network. The second group are the one person households, which are more vulnerable due to their high mobility needs and potentially lower financial capabilities. The household composition is not specified in the model, which is a potential subject for improvement. The third group are the individuals with low-literacy capabilities. These individuals experience more difficulties when using the public transport network. The surveys do not caption this group for the reason that these individuals presumable find it more difficult to fill out an extensive survey. The fourth group are the students in rural areas. They often have to travel further to school due to few school options. This includes high school and university. It becomes problematic when regarding the lower public transport availability and reliability in rural areas. The last group, which is missing according to the policymakers, are the low-income individuals. When looking at the descriptive analysis, it is clear that the average household income of the individuals in the surveys is significantly higher than the national average.

6.2 Policy experiment

This section will use the groups constructed from the LCA as a thought experiment for policymaker. Specifically, to indicate the effect of potential policies on the transport disparities in the Netherlands. It allows policymakers to put their policy ideas alongside the groups to test the outcomes. This research is done at a particularly important time in Dutch politics that elevates the effectiveness of such an experiment. For the governmental elections on the 22nd of November, all the political parties published their policy strategies. This research will apply the policy packages of three political parties on two major topics, 'car and road' and 'public transport and rail' (AAPM, 2023; GroenLinks PvdA, 2023; PVV, 2023; VVD, 2023).

6.2.1 Car and road

For the analysis of the mobility policy packages regarding car and road, it is important to rank the car use indicator and the household income. Car use is measured in the number of kilometers driven in a car. Table 16 present the ranking of the group on the amount of car use and household income. It is noticeable that groups five, one and two are amongst the highest car users, when also regarding the fact that these groups have the highest household incomes. In addition, groups one and two have relatively high public transport accessibility which means the possibility to use alternative transportation. This ranking is evident in the analysis of the car and road policies of the political parties.

Table 16: cluster ranking on car use and income.

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Cluster9	Cluster10	Cluster11
Car use	2	4	7	3	1	6	5	9	6	4	8
Income	3	2	10	9	1	5	6	11	8	4	7

VVD

The first policy packages that will be evaluated is that of the VVD. It includes four relevant policies which could have an effect on the groups. The policies are road pricing, which is an important topic across all parties, investing in both maintenance and building new infrastructure, lower excise tax on fuel and lower costs of travelling from and to work. Road pricing will mean the removal of the road tax which every car owner has to pay, no matter how high the use, and the introduction of road pricing for which the car owner will have to pay a price per kilometer driven. There are also variants in the road pricing intervention. The variant that is preferred by the VVD is to have the same price per kilometer across the day (Kilometerheffing Nederland, 2023; Wegenwiki, 2023).

Road pricing will mean that car use will become more expensive for the individuals who use it the most and less expensive for those who use it less. The implementation of the road pricing will come with the removal of the current vehicle tax system. For the groups, road pricing will result in that group one, two, four and group five will have to pay more for their car use. Groups one, two and five are also the groups which are deemed to have the least transport vulnerabilities. Group three has the least car use of the groups that have a substantial percentage of car ownership, which means that these individuals will pay less. This is fortunate when regarding the affordability is relatively low and the experience of forced car ownership is relatively present. Another effect of road pricing is that the purchase of a car will become more appealing. This is the results from the removal of the standard vehicle tax which is a fixed amount

based on the vehicle (MinAZ, 2023). This also presumably has positive effects for group three as car ownership is significantly lower and health hinderance for the use of the active modes is relatively high.

Building new roads, lowering the excise tax on fuel and making the trip to work less expensive will proportional have the most effect on groups one, two and five. These groups have the highest car ownership, car use and the highest share of individuals with paid employment. They do also, have the highest income and transport affordability of all groups. In particular groups nine and ten, will also experience a positive effect. These groups have high car ownership and car use but in contrast to the previous mentioned groups, have relatively low transport affordability and high experience of forced car ownership.

All in all, the policy package of the VVD will have varied effects on the transport disparities. Road pricing will increase the costs of car use for groups one and five and decrease the cost for group three. This will narrow the transport disparity as groups one and five are the most transport 'fortunate' and groups three experiences multiple vulnerabilities, including affordability. This effect could be partially negated through the introduction of new roads, lower fuel prices and lower costs of work commute. These policies have proportionally the most effect of the most 'fortunate' groups, one, two and five. However, groups nine and ten will also benefit from these policies as they experience vulnerability issues and are more car dependent for work commute with the accessibility being relatively low.

Groenlinks-Pvda

The second policy package to evaluate is from the Groenlinks-Pvda partnership. Their relevant policies are road pricing with dynamic pricing and to not built additional roads. The dynamic road pricing will introduce different prices per kilometer drives according to the time of day and area of residence. When the roads are most congested, the prices will be higher. For residence in areas which are more car dependent, the prices will also be lower. This variant of road pricing increases the costs of car use for the groups one and five even more as they have the highest share of individuals with paid employment. This means they often have to travel by car on times when the roads are most congested.

The differentiation on residence areas, will have a positive effect on groups nine and ten. These individuals are more car dependent as distances to employment and other activities are high. They also experience vulnerability with their transport affordability, which will increase with this variant of road pricing. The plan of not building new roads, in particular the expansion of the A27 highway, will have effect on groups one, two and five as they have the most car use and the highest share of individuals with paid employment.

The policy strategy of the Groenlinks-Pvda collaboration will decrease the transport disparities when regarding car and road policies. The groups that have the highest car use and also drive at the times when the roads are most congested, will be affected with an increase in costs. The groups are one, two and five. For groups with less car use that do not drive at these busy times of day, the costs will decrease.

PVV

The third policy package to evaluate are the policies of the PVV, which won the last elections. The PVV takes a different approach to car and road policies than the rest of the political parties. They want to negate all policies which impact the car user. This means no road pricing, the construction of more roads and the reduction of the excise tax of fuel. These policies will have the most effect on the groups with the highest car use and that travel on the most congested times of day, groups one, two and three. These groups also have the highest income and transport affordability of all groups. The lowering of the fuel prices will also benefit groups nine and ten which are more car dependent, have lower transport

affordability and experience more forced car ownership. The other groups with relatively high car use are not significantly affected as affordability is already adequate and accessibilty is higher.
It is clear that the policy strategy on 'car and road' of the PVV will increase the transport disparity in the Netherlands according to the groups. The policies benefit the groups with already the highest affordability the most as they have the highest car use and travel at times when it is most congested. Groups four, nine and ten which have relatively high affordability vulnerability will also benefit from the lower fuel cost.

6.2.2 Public transport and rail

Table 17 presents the ranking of the groups based on their train use, BTM use and income. This ranking is provides a cheat sheet to help with the evaluation of the policies regarding public transport and rail.

Table 17: cluster ranking on train use, BTM use and income.

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Cluster9	Cluster10	Cluster11
Train use	5	3	7	6	6	4	8	2	9	7	1
BTM use	6	4	5	3	7	5	8	2	9	7	1
Income	3	2	10	9	1	5	6	11	8	4	7

VVD

The first package on 'public transport and rail' to evaluate is from the VVD. This package is focused on the affordability and accessibility of public transport. This includes the accessibility of both urban and rural areas, public transport for specific groups and the cost of work commute. Investing in the improvement of the accessibility and efficiency of public transport will potentially provide groups one, two, four, six, seven, nine and ten with an appealing alternative to the car as these groups have a high percentage car ownership and car use. The distance a to access point of the public transport network is relatively high for groups seven, nine and ten. Combining the increased accessibility and efficiency with decreasing the costs of work commute, could improve the attractiveness of public transport for groups nine and ten for which inaccessibility and unaffordability causes a double barrier. This will increase the overall mobility of these groups as they have more options to travel.

Decreasing the cost of work commute will have the most effect on groups eight and eleven. These groups have the highest public transport use of all groups and include a substantial share of individuals who have paid employment. However, these groups are not vulnerable in their affordability. The safeguarding of the mobility of targeted groups, will have beneficial effects for group three, which includes older individuals with lower public transport accessibility, Targeted groups include individuals who are mentally or physically incapable of travelling with conventional transportation. Group three includes individuals who indicates to experience mobility hinderance due to their health and may therefore be more often in need for such special transportation. Especially in the future with increasing age and decreasing health.

To summarize, the improved accessibility and affordability for all areas will provide groups for which public transport is not yet an option, with the potential to use it. It will therefore decrease the transport inequality in the Netherlands. The reduction in cost of work commute will proportionally have the most effect on the already most 'fortunate' groups as they have the highest percentage of individuals with paid employment. So this this presumably increase transport inequality.

Groenlinks-Pvda

The second package of public transport is that of the Groenlinks-Pvda partnership. The Groenlinks party is known for its progressive environmental policies and are therefore great advocated of public transport. The subscription will decrease the travel costs of public transport to help it become a viable alternative to the car. The subscription will cause the individuals' costs of public transport to decrease with an increase in use.. This is especially true when forcing employers to compensate for all costs resulting from work commute. Groups one, two, four and six. These groups have high car ownership but also relatively good public transport accessibility.

Another important part of the policy strategy is increasing the accessibility of rural areas by setting a 45-minute limit on accessing a hospital, school and supermarket. This will increase the accessibility of activities of groups seven, nine and especially ten. Distances to activities are relatively high for these groups as well as lower public transport accessibility. This means that the car is most used by the individuals. Increasing both the affordability and accessibility of public transport for these individuals could encourage them to use this mode to access the activities. This could also be an interesting policy intervention as the access of activities is one of the most important parts of transport poverty.

The policy package of the Groenlinks-Pvda has two important parts which could decrease the transport disparity. The first is the 49-euro subscription, for which public transport becomes cheaper with increasing use. Combining this with an increasing accessibility could possibly decrease the disparity of the relative inaccessibility and unaffordability of public transport for groups nine and ten. The accessibility of the rural areas is increased with the implementation of a limit of 45 minutes for accessing a hospital, school and supermarket as this is not the case for everyone in the Netherlands (Bastiaanssen & Breedijk, 2022).

7. Discussion and conclusions

The last chapter presents the discussion and conclusion of this research. First, the sub research questions are individually answered, ultimately answering the main research question. Second, the discussion of the results provides a comparison of the results of this research with the results of past literature. Third, the research contributions and political implications are presented. This research concludes with a reflection on the methodology, surveys and results along with recommendation for future research.

7.1 Research questions conclusion

SQ1: What is the conceptual model of transport poverty risk when accounting for the individualism and factorial complexity?

The first research question aims to establish a comprehensive definition and to construct a conceptual model on transport poverty risk. This is done so that the entire complexity of the concept can be included in the next phases of the research. Transport poverty risk is a complex concept which includes different notions of factors, individual transport needs and capabilities and consequences for the well-being. This research utilizes the three notions of transport poverty provided by Lucas et al. (2016) in order to categorize the many different factors that are important in shaping the concept. These three notions are used throughout the literature and are form therefore strong base of the definition. Furthermore, it is important to acknowledge and include the consequences of experiencing transport poverty risk. The individual's purpose of making a trip is to access essential locations such as the doctor, supermarket or social contacts. Transport poverty will then cause the unfulfillment of the transport needs and therefore the risk of social exclusion and a decline in well-being. The factors that are used by the literature are also included in the conceptual model to form a theoretical base for the identification of indicators in the MPN and ODiN datasets, which will be done in the next research question.

SQ2: Which indicators of transport poverty risk are suitable and available to use in the Netherlands?

After conducting the literature review and constructing the conceptual model, this next step identifies which indicators and personal attributes within the national surveys of the Netherlands are available for the transport poverty risk analysis. The ODiN dataset does not include sufficient indicators from all three notions (affordability, accessibility and mobility) for an effective Latent Cluster Analysis. The MPN dataset does include a large number of potential indicators which relate to the three notions, even though the survey was not constructed for this purpose. There are however several factors from the conceptual model that are missing from the MPN survey. These are travel time, activity participation, the exact transport expenses per modality, the ability to use the digital aspects of transport systems and the ability to repair certain modes of transport. Travel distance is seen as an adequate replacement for travel time. However, only travel distance in a car as the driver is available in the MPN. The car is the most used modality in the country, which means that this research accepts this shortcoming. The activity participation is an important part in the identification whether an individual has had problems accessing the essential activities. Although this indicator is missing from the MPN survey, the ODiN integration can fix this shortcoming and provide an indication on past transport problems. Lastly, the missing of exact transport expenses is seen as an important shortcoming. The MPN includes questions about the perception of the affordability of the overall mobility, car and public transport. This does not allow for analysis on how the exact transport expenses differ between groups and areas. All in all, the MPN dataset is suitable for fulfilling the conceptual model on transport poverty risk and therefore to utilize in the Latent Cluster Analysis for the construction of the complex transport vulnerability groups.

SQ3: Which groups in the Netherlands have transport vulnerabilities according to the groups?

To answer this sub research question, the LCA model is executed. The model returns eleven groups regarding the incorporated factors that capture the affordability, accessibility and mobility levels of individuals. In order to create a structured overview, this research has manufactured simple visualizations of each group were the levels of the three notions with the most interesting particularities and the personal attributes are presented. After which the discussions of the groups are presented which do not include a dull enumeration of its indicator values but rather an analytic and processing approach. The examining of the groups independently and of all groups as a national picture, does result in several interesting findings. Groups three, which include older individuals who live in suburban areas, experience more health hinderance, with relatively low car ownership and low household income, seem to be especially transport vulnerable. Additionally, group three also has higher distances to the train station and hospital which increases their transport vulnerabilities.

Groups nine and ten also have substantial transport vulnerabilities. This is most likely the result of their rural residence area. This means that distances to essential activities are relatively high. This also results in the public transport affordability being relatively low, which creates a double barrier of the use of the public transport network. The vulnerability created by the residence areas is presumably compensated by car ownership as car use is also relatively high. This means that these individuals are still able to reach their essential activities and are not at risk of transport problems. However, car dependency may lead to future vulnerability as costs could increase or the individual could become incapable of driving a car.'

Lastly, there are three group that are especially transport 'fortunate'. These are groups one, two and five. These groups have high household income and affordability, partly high accessibility of activities and high car ownership. Additionally, they also have the potential of using other modalities in public transport and the bicycle. Combining this with the fact that a high percentage has paid employment and mobility health hinderance is minimal, results in the conclusion that these group have no transport vulnerabilities. Group five individuals do have relatively high distances to activities and public transport, however this is easily compensated by higher car use and the highest household income of all groups.

SQ4: Have these groups experienced transport problems in the past?

The limitation of using the MPN dataset is the inability to identify whether the groups have experienced transport problems in the past and how they view their own mobility levels. It is valuable to be able to understand how the levels of the three notions (affordability, accessibility and mobility) translate to actual transport problems. In additions, the perceived satisfaction of the mobility levels could provide this research with information on whether the inability of accessing essential activities and the presence of transport vulnerabilities translate to a feeling of dissatisfaction. This could be a careful indication on the effect on the well-being of the individuals. The groups who have the highest percentage of individuals who have indicated to have experienced problems accessing certain essential activities are groups three, four, seven and eight. Group three is expected as the cluster analysis revealed several transport vulnerabilities in this group. Groups four and eight as fairly surprising as they are located in urban areas with high accessibility, have good affordability and high mobility levels. For group eight, this could highlight the need for a car for linger distances as a relatively high percentage indicate to have had problems accessing family members.

The mobility satisfaction levels in most part match the group vulnerability analysis and the ODiN integration. However, the findings include two interesting results. The higher distances to activities of group seven and the accompanying higher percentage of inaccessibility of activities, does not translate to higher dissatisfaction levels. This could be explained by the higher household income which could

provide them with more possibilities like the delivery of groceries. The links between higher inaccessibility percentages of group eleven and the satisfaction levels makes more sense. The ODiN integration reveal higher percentages of the inaccessibility of the hospital, doctor and public transport. Apparently, the daily activities are still adequate accessible, most likely due to car ownership, which is also visible in the satisfaction levels of conducting these daily activities. The satisfaction of their overall mobility levels is however lower compared to the other groups.

SQ5: Based on the groups, what are the transport vulnerabilities according to policymakers?

The consultation with the policymakers are used for two purposes. Firstly, two identify additional, more specific transport vulnerabilities which are not initially discovered by the cluster analysis and secondly for providing feedback on the quality of the groups. The policymakers identified several additional transport vulnerabilities. The first being the combination of older individuals and car dependency. This is especially true for group three, which highlights the level of vulnerability resulting from the cluster analysis, ODiN integration and satisfaction levels. The second vulnerability is the importance of a social safety net. Regarding group eight, relatively many individuals are living alone which creates the vulnerability that they more often cannot rely on someone else for transportation when something happens or to tag along when the other has a car. The last vulnerability according to the policymakers emphasize the social aspects of transport poverty risk. This vulnerability has two directions. The first direction is associated with groups eight and elevens which includes individuals who do not own a car but have high use of the other modalities with most often provides them with adequate mobility to access the essential activities. However, the location of their social contacts and therefore a large part of their social life, cannot be chosen. It is their responsibility to access these contacts. A reliance on public transport means linger travel times and high travel costs. The other direction is associated with the groups who are located in rural areas, groups five, nine and ten. Even though these groups have high car ownership and therefore have the ability to reach all essential activities, it is more difficult for other individuals, such as family and friends, to access their residence areas. This could ultimately result in social isolation when the ability to use the car decreases.

The feedback on the quality of the groups reveals several missing societal groups from the analyses. This is confirmed by the descriptive analyses and the limitations of the two surveys and will further be elaborated in section 7.5. The missing groups are non-Dutch citizens, one person household, individuals with low-literacy capabilities and lastly students in rural areas.

SQ6: What is the effect of future mobility policies on the potential transport disparities between the groups?

The last sub question includes the use of the groups as a thought experiment to indicate the effect of future policies on the transport inequality. In light of the current political coalition formation period, this research has applied the policy packages of three political parties on car and road and public transport and rail. Concrete plan on public transport and rail are missing from the PVV's policy strategy and is therefore not evaluated. The main findings are that the policies road pricing (especially with dynamic pricing) and the 49-euro public transport subscription will reduce the transport inequality. The reason is that the most transport 'fortunate' groups (one, two and five) will have to pay more for their car use which is the most of all groups. On the other hand, the reduction of the excise tax of fuel and the construction of new road will only increase the transport inequality as the most transport 'fortunate' groups who also have the highest car use benefit the most.

What are the transport vulnerability groups associated with transport poverty risk in the Netherlands and how do future mobility policies affect transport inequality?

The sub research questions present the structure in which the main research question can be answered. The main research question can be divided into two parts. The first part includes the statistical model to construct the latent groups of transport poverty risk and transport vulnerabilities. The second part uses these latent groups as a thought experiment to indicate the effect of potential policies regarding mobility in the Netherlands. This research reveals eleven groups that represent transport poverty risk in the Netherlands. The majority of the groups do not experience transport vulnerabilities. Group three does experience current transport vulnerabilities as health hinderance in combination with car dependency is present and that they have had transport problems in the past. The inequality in the Netherlands is mainly represented by the differences between groups one, two and five and the rest. Groups one, two and five are the most transport 'fortunate' as they include individuals who have a high household income, relatively low distances to public transport and essential activities and high car ownership and use.

Road policies which improve the costs or comfort of car use per kilometer, such as the decline in excise tax on fuel and the construction of new roads, mostly favor the groups that have the highest car use, which are already the groups that are most 'fortunate'. Dynamic road pricing on the other hand, does shift the costs of driving a car from car users with the least use to the highest users. The reason is that the vehicle tax which every individual with a car needs to pay is replaced with a price per driven kilometer. Groups with high car ownership also have higher car use and the two groups with low high ownership already have high public transport use. The introduction of a maximum monthly price or a subscription of public transport seems to reduce transport inequality. All groups could therefore benefit from the reduction in cost, but especially groups eight and eleven, which have the highest use of public transport.

7.2 Discussion

The focus of this research has been to apply the Dutch national mobility surveys to a comprehensive definition and conceptual model of transport poverty risk in order to identify transport vulnerabilities and transport inequality. There have been other scientific papers that aim to quantify transport poverty risk and transport disparities. This section compares the findings of the past literature to the findings of this paper in order to reflect on the differences and similarities. The literature assesses the population based a limited number of pre-selected factors (Allen & Farber, 2019, 2020a; Jeekel & Martens, 2017; Kelly et al., 2023; Lowans et al., 2023; Lunke, 2022; van Dülmen et al., 2022). For example, the analysis of low-income neighborhoods, rural areas or non-car owners. It is however important to assess transport disparities with the complexity that comes with combining the many different factors. Only including rural areas means discarding the differences in income and car ownership in these rural areas. This can result in the misinterpretation of groups as having transport poverty risk. For assessing transport poverty risk, this research argues that the wide range of factors are essential in identifying such risk. Whether an individual experiences problems accessing essential locations is not only dependent on car ownership or accessibility but also on the individual needs, capabilities and habits (Kaufmann et al., 2004; Martens et al., 2022).

Kelly et al. (2023) come close to the comprehensive definition by constructing a transport poverty risk index (TPRI), which includes indicators from the three important transport poverty notions provided by Lucas et al. (2016). The TPRI includes affordability, accessibility and mobility indicators, and is constructed in order to assess the effect of different sustainability policies in Ireland. This paper also finds the disparity between urban and rural areas as rural areas experience higher transport costs, longer travel times and are more car dependent. This research also discovers that when regarding the individual attributes within these areas, there is a group of individuals living in more rural areas that do not have transport vulnerabilities. Group five includes individuals who have high income, own a car and have not experienced problems in the past. This shows the need for including individualism in the assessment of transport poverty risk. Dülmen et al. (2022) acknowledge this in their study as they analyze the mobility behavior of three social disadvantaged groups located in rural areas of Germany and the Czech Republic. They conclude that disadvantages in individual aspects matter more than regional spatial disadvantages. The study further concludes that the car is not only essential for mobility levels but also a socially conditioned variable. Similar results can be found in group three of this research where individuals are relatively old in age and experience more health hinderance of active travel model. This indicates dependency on the car to access essential destinations and participate in social life.

Low-income areas are another important research subject in the literature. The findings of Lunke (2022) show that less affluent areas, in the Oslo region, have lower accessibility levels and higher travel times of public transport. He further concludes that this means that transport poverty is transferred to the suburban areas where the accessibility and public transport access is lower. This highlights the car dependency of those neighborhoods. Allen & Farber (2020) also find that in Toronto low-income households are concentrating in more car-oriented areas with lower accessibility. These findings are similar to group three which includes individuals who live in suburban areas with lower public transport accessibility, relatively low car ownership and below average household income. The last two are problematic in these car dependent areas. However, groups one, six and eleven are also located in suburban areas and are not in any way transport vulnerable. This is the result of relatively high household income and high car ownership. The findings of Allen & Farber (2020) do confirm the problems resulting from a combination of less accessible areas and lower household income.

Jeekel & Martens (2017) conducted a thought experiment to provide a rough estimate of the percentage of households in developed Northern-European countries that are at risk of transport poverty. They estimate that nine to eleven percent of households suffer from transport poverty risk. The basis of the estimation is car ownership and car affordability. Even though this estimation does not include the use of other travel modes or the accessibility of public transport and essential activities, it highlights the disparity between car owners and non-car owners. This disparity is also found by this research, individuals who own a car are in general not deemed as being vulnerable in their mobility levels as a car is able to transport them anywhere at any time.

The quantitative literature has found different versions of transport inequalities in their respective countries. These inequalities are mainly caused by residence area, low-income, car ownership or a combination of two of the three ((Allen & Farber, 2019, 2020b; Kelly et al., 2023; Lowans et al., 2023; Pérez-Peña et al., 2021; van Dülmen et al., 2022)). The qualitative literature also defines the factors of inequality as important in shaping transport poverty risk (Dorantes & Murauskaite-Bull, 2023; KiM, 2018b, 2023b; Lucas, 2019; Lucas et al., 2016; MeJía Dorantes & Murauskaite-Bull, 2022). They also include health and public transport access as important factors. In the LCA, a wide range of factors were included. It is possible to determine which factors were significant in constructing the eleven groups by examining the R squared value for the indicators. This value reveals that like in the literature residence area, car ownership, health hinderance and public transport access are especially important. Interestingly, the income and affordability indicators are not important within the group construction. This could be a misinterpretation as the average household income in the MPN and ODiN dataset are higher than the national average. The findings of this research indicate that transport inequality and transport problems have to be analyzed by all important factors. A composition of less than the total of the factors results in a less accurate representation which can results in the exclusion of possible reasons that an individuals could experience transport problems. For example, group eight includes individuals who do not own a car and have a low household income. The fact that the essential activities are close by, and bicycle ownership and use are high, means that the individuals is still mostly able to access these essential activities. This research therefore acknowledges and confirms the disparities found in the literature but in turn proofs that analysis calls for a complex approach to fully understand the context. This allows for the correct interpretation of transport poverty risk and therefore misplaced policy can be avoided.

A study on the individual level was conducted by Fransen et al. (2021) with a groups analysis on less mobile Belgium citizens. The study defines less mobile persons when they do not travel at least two days a week. The study finds five different groups of individuals based on their personal attributes. These five groups can also be found in the Latent Cluster Analysis of these research. This acts as a careful validation of the link between indicators of accessibility, affordability and mobility and the personal attributes. This is very interesting regarding the fact that Fransen et al. (2021) only included individuals who already travelled less, and this research includes all individuals. The groups ‘mobile elderly’, ‘young starters’ and ‘urban public transport dependent’ are found by this research but do not represent groups that have transport vulnerabilities. This raises the concern that it is unclear whether the fact that these individuals who do not travel at least two days a week in fact experience transport problems. Including the whole complexity and context in the LCA, reveals that these groups do not experience substantial transport poverty risk when regarding their levels of affordability, accessibility and mobility. The two groups ‘suburban car dependent’ and ‘elderly in rural areas’ are also found by the LCA and also have transport vulnerabilities.

A valid concern regarding a research on ‘poverty’ is whether the theory can be applied on a developed country as the Netherlands where two thirds of the households own a car (MinIenW, 2023b), the average household income is eighty thousand euro (CBS, 2022a) and where the bicycle is a cheap alternative to

access essential activities (Martens, 2011b). The results from the MPN national surveys confirm this 'transport wealth' as 95.8 percents indicates to be satisfied with the way he or she can get around and 96.1 percents indicates to easily conduct their daily activities. It is difficult to capture the remaining four percent in a group based analysis on national level. Quantitative studies in other developed countries such as the United Kingdom, Germany and Ireland, analyze the amount of risk and the inequalities caused by factors such as car ownership, not the absolute percentage of transport poverty. It is important to underline the intended outcome of applying the transport poverty theory. Due to the high complexity of the concept transport poverty combined with relatively high wealth of these countries, it is only possible to examine transport poverty as risk and transport inequalities. This research also investigates which groups in society are more vulnerable to transport problems, meaning whether they lack affordability, accessibility and/or mobility. In order to fully understand the link between the vulnerabilities based to the three transport poverty notions, satisfaction and the experience of past transport problems, this research has included two additional approaches besides a Latent Class Analysis. Questions about the ability to access essential activities and about the mobility satisfaction are integrated in the groups resulting from the LCA. This integration of three approaches shows the complexity in which transport poverty risk is placed to answer the questions whether someone was actually not able to access certain locations and whether the potential lower levels of for example mobility actually translates to lower satisfaction on that mobility. This additional complexity on top of the individualism has not been done in past studies and provides interesting results. The analysis of rural areas is thereby the most interesting and clear example of the interaction between transport indicators, past transport problems and mobility satisfaction. The indicators reveal that the groups in rural areas have very high distances to essential activities which presumably results in the lower affordability levels and high car ownership. Even though these individuals experience more barriers for accessing essential activities, the percentage of these individuals that have indicated to have had actual problems accessing these activities in the past, is relatively low. This result corresponds with the study of Pot et al. (2023) in which he finds that perceived accessibility levels in Dutch rural areas are high on average. This research adds the link of these findings to the satisfaction levels. In the most rural areas, the satisfaction of the ability to conduct daily activities is average. However, the percentage of individuals who indicate to be dissatisfied with their overall mobility, is the highest for the groups that are located in rural areas. This is presumable the result of the lack of alternative transport modes and longer travel times. This raises the question whether the lower satisfaction level is problematic regarding the fact that the car still allows these individuals to access their essential activities.

The complex understanding of the context within transport poverty risk allows policymakers to examine in which subject area and what societal group further policy development is necessary. Furthermore, it provides policymakers a first screening experiment for potential policies indicate the effect on transport inequality. Examining the policy packages of different political parties in regard to the ongoing coalition formation period, finds that road pricing and subscription on public transport are effective in reducing the gap. The report from Voerknecht & van der Kooij (2023) also found that a maximum price on public transport is most effective. However, not in the shape of a subscription but a price ceiling after which the individuals' public transport trips are free of charge. With the current attention around the subject of transport inequality and accessibility for all, policy thought experiment provided by the groups could act for an efficient first qualitative assessment for future policies.

7.3 Research contribution and implications

This research has several contributions to the scientific literature on transport poverty risk and transport inequality. In addition, this research has resulted in various political and societal implications. These contributions and implications are outlined in this section.

This research constructs a comprehensive definition and conceptual model, which is different from past literature. The past literature has not (or to a lesser extent) included all three aspects of the definition of transport poverty risk in their research: the factor categories (affordability, accessibility and mobility), the inability to access activities and participate in society and the individual nature of the concept. The different perspectives on transport poverty risk and the use of different definitions in the literature clarify the need of a comprehensive definition which incorporates the entire complexity (Kaufmann et al., 2004; Kenyon et al., 2002; KiM, 2018a; Lucas, 2018; Van Der Bijl, 2020). The conceptual model visualizes the definition, clarifies the difference between transport vulnerability and transport problems and contains specific factors to measure the affordability, accessibility and mobility levels of an individual. The conceptual model can be used to test to what extent a dataset is able to capture the complexity of transport poverty risk. This research used the model to conclude that the ODiN dataset is not suitable for the construction of the vulnerability groups. The model also showed that the MPN dataset does fit the conceptual model and is suitable for the construction of the groups.

This research uses the Latent Cluster Analysis methodology to construct the vulnerability groups in the Netherlands, which to the knowledge of this research this has not been done before. The statistical method allows for the construction of the vulnerability groups based on the patterns of the individuals' values on the indicators. This results in the post-hoc construction of the groups which means that the societal situation is not based on a limited number of pre-selected variables. LCA allows to include personal attributes in order to identify the individuals and to discover the types of individuals that are part of each group. Thus LCA is an effective method to account for the individualism and the wide range of indicators. In addition, this research contributes an innovative approach to integrate a second national dataset in the LCA approach. The ODiN dataset is not suitable for constructing the complex vulnerability groups but does contain important indications on past transport problems of individuals. This part of the analysis is important to eventually determine which groups have transport vulnerabilities and experience transport problems. The ODiN dataset is integrated through the use of the same personal attributes that are used in the LCA model with the MPN survey. The ODiN dataset is then integrated through the probability function, which calculates the probability that an individual is part of a group. This results in the distribution of the ODiN individuals over the groups and thus providing an indication of the extent of past transport problems for every group.

The second political and societal implication comes from the application of the identified transport inequalities and transport vulnerabilities. The vulnerability groups are used as a thought experiment to indicate the effects of future mobility policies on the transport inequality in the Netherlands. In light of the current political formation period and the to be written coalition agreement, the thought experiment is applied to the mobility policy packages of three political parties. Transport inequality and accessibility for all has become an important discussion point in politics, thus this experiment allows policymakers to test their policies as the use of the MPN and ODiN datasets results in a national representation of the groups and inequality.

7.4 Limitations

This research has produced various scientific contributions and political and societal implications which can be valuable for future research and policymakers. However, as in any research, it includes several limitations which have to be addressed. Not addressing these assumptions and limitations can result in misinterpretation of this research and its results. These assumptions and limitations will be outlined in this section.

The first limitation is based on the literature review. The theoretical analysis chapter and therefore the formulation of the comprehensive definition of transport poverty risk and the construction of the conceptual model, is based on a literature review on transport poverty. Within the literature, this research identified several factors that had been used in quantitative research, which are included in the conceptual model. However, this research formulated its scope around the transport poverty literature. This results in an uncertainty whether all 'relevant' literature has been identified and included in the research. Individual topics such as 'transport accessibility', 'transport affordability', 'mobility' and 'social exclusion' include another large dimension of scientific literature that are possibly relevant to this research. It is important to note that the transport poverty literature, including the literature reviews, already aim to capture these topics and thus providing this research with the relevant information.

The second limitation results from the use of the MPN and ODiN survey. Although these national surveys contain a high number of indicators related to and included in the conceptual model of transport poverty risk, these are several missing elements which can impact the results. The descriptive analysis in section 4.2.1 reveals that some societal groups are under- or overrepresented in these surveys compared to the actual national percentages. Mainly non-Dutch citizens, one person households and paid employees are underrepresented in these surveys. It is important to acknowledge these shortcomings in order to avoid misinterpretation and in this case under-assess transport poverty risk in the Netherlands. The policymakers indicate that several specific types of individuals are missing from the analysis. Non-Dutch speaking, low-literate, one person household, digital disadvantages and the very low-income individuals are not or less included in the research and are missing from the results. Part of the reason is the manner of conducting the surveys, which is in the Dutch language and online. The other part is the characteristics of the respondents, in which the one person households are underrepresented. These types of individuals are prone to be more difficult to identify through the use of a survey and a more specific and elaborate survey method may be necessary. It can therefore be argued for that these national surveys are able to represent the national 'average' but not in lesser sense the groups in society which are automatically more prone to transport vulnerabilities.

Although the surveys are not designed to capture transport poverty risk, they include the vast majority of indicators that are used in the transport poverty risk literature and included in the conceptual model. However, information on travel time and specific costs per travel mode is missing. Travel time is partly captured by the travel distance as a car driver, therefore travel time of distance with other travel modes is missing from the research. This could have provided this research with valuable information of the attractiveness and choice trade-off of every travel mode. The specific costs are captured by perceptions on the affordability of overall mobility, car and public transport. This however leaves a gap of the difference in costs per societal group and residence area, which would have been interesting information.

The third limitation is based on the utilization of the Latent Cluster Analysis methodology. In the construction and formulation of the LCA model, it is important to assess the correlations between the indicators. This assessment is a constant trade-off between the theoretical optimization of finding the best model and the practical optimization of finding the best real-world representation. The goal of the

research is to apply the results of the statistical model on the situation in the Netherlands. To find applicable results, the theoretical model also has to be correct. As specified in section 4.3.1, this research has included several indicators which have relatively high correlations. This begs the question whether the LCA model with the high number of indicators is not too complex. To include this many indicators in a LCA model is unconventional regarding past LCA approaches. However, it is important to acknowledge the purpose of this research, which is to capture the full complexity of the transport poverty risk concept. In additional, the integration of the ODiN dataset through the cluster probability function is also unconventional. The uncertainty in this approach results from the fact that the individuals in the MPN dataset are different from the individuals in the ODiN survey. The placement of the individuals in the ODiN dataset in the latent groups that are based on the individuals in the MPN dataset is therefore accompanied by uncertainty of the accuracy. It is however important no note that the overall characteristics of the individuals of both surveys are comparable, increasing the accuracy.

7.5 Research and policy recommendations

In this section, this research will formulate several recommendations for both future research and policy related. These recommendations are the outcome of the acquired results through the LCA, the scientific contributions and political implications and the limitations.

7.5.1 Future research recommendations

The first part are the future research recommendations. The LCA model used in the analysis is extensive with many different indicators to represent the levels of affordability, accessibility and mobility. The size of the model has negative consequences for the interpretation of the results and for the correlations between indicators. It could therefore be beneficial to simplify the model through the reduction of the indicators to a single factor for each of the three notions. This will, however, reduce transparency of the research which will have a negative impact on policy formulation. In addition, future research could reverse the research, so first performing the latent cluster analysis based on the satisfaction indicators and then integrate the transport poverty risk indicators to investigate the reasons behind the satisfaction values.

Another recommendation for future research is the integration of other surveys with the use of the cluster probability function. Through such an integration, the advantages of different surveys can be combined in one analysis. It is however important that the surveys are comparable in overall characteristics, otherwise it will lead to poor results. This research recommends identifying the corresponding personal attributes of the different surveys, to optimize the integration. Given that the personal attributes are the same and the characteristics are comparable, the integration can even be done with surveys of another country.

The last research recommendation is to perform this research with more area or individual specific surveys instead of a national representation. But still include the wide range of indicators. An effective survey could be to identify the most vulnerable groups, such as one person household, non-Dutch citizens and low-income individuals, and to conduct a transport poverty risk survey based on the conceptual model. This means that the theory of transport poverty will then be applied on the individuals who are directly more at risk. Such research would be more specific to transport poverty and not focused on transport inequality. The difficulty is to identify these more at-risk individuals and would certainly result in high research costs. However, completing the research would most likely result in tangible policy opportunities specific for the individuals who are most in need of those policies.

7.5.2 Policy recommendations

The first policy recommendation is to differentiate on which government level respectively transport inequality and transport poverty have to be addressed. Within the Ministry of Infrastructure and Water Management, this will mean differentiating the concepts transport inequality and accessibility for all. Accessibility for all (or transport poverty risk, transport problems) refers to the individual's ability to access destination. Transport inequality in turn refers to the, in this case, national differences of levels of transport problems between certain groups. This shows that transport problems call for specific measures according to the individuals needs and capabilities. This research indicates that transport inequality can be analyzed on national level, resulting in the eleven groups. Policies can then be formulated to tackle the transport inequality, such as dynamic road pricing and a subscription on public transport. This research recommends addressing the problem of transport poverty on lower level of government, municipality or state level. The municipality is better able to identify the specific individuals and neighborhoods that are more at risk and formulate the policies accordingly. These policies can be more specific such as gifting bicycles, public transport discount for elderly or a subsidy

for the purchase of a car. Policies on a lower level and focused on transport poverty risk, will be valuable to address the real problems of specific individuals.

The second policy recommendation is to further elaborate and use the policy thought experiment for potential policies regarding mobility. The groups can be used to indicate the effects of policy on transport inequality. It gives policymakers a first screening of their policies in national context. This results in the third policy recommendation, which is to focus transport inequality tackling policies on the amount of car use. This will have implications for car policies that proportionally benefit the highest users the most, who are already the most transport 'fortunate'. Although all car users would benefit from such policies, the transport inequality will increase. Policies should therefore either be tailor made for the less transport 'fortunate' or partly shift the costs from the least users to the highest users. This will result in a decrease of the transport inequality in the Netherlands. The policy thought experiment, based on the eleven groups, is a valuable way for policymakers to first assess potential mobility policies.

The third policy recommendation is to conduct a specialized survey to best capture the transport inequality and transport problems in the Netherlands. This means that the missing parts from the MPN dataset have to be implemented. These are the specific travel costs per mode of transport, travel times per mode of transport, the ability to use the digital aspect of the transport systems and the ability to repair certain modes of transport. In addition, the specialized survey could focus more on the at risk population. This means that the survey should be in different languages and also be taken by letter and personal interview. Including the now missing indicators will provide policymakers with additional context to determine what policies are necessary and effective. Focusing the survey more on at risk population, can provide policymakers with knowledge on who these individuals are and more specific reasons on why they experience transport vulnerabilities.

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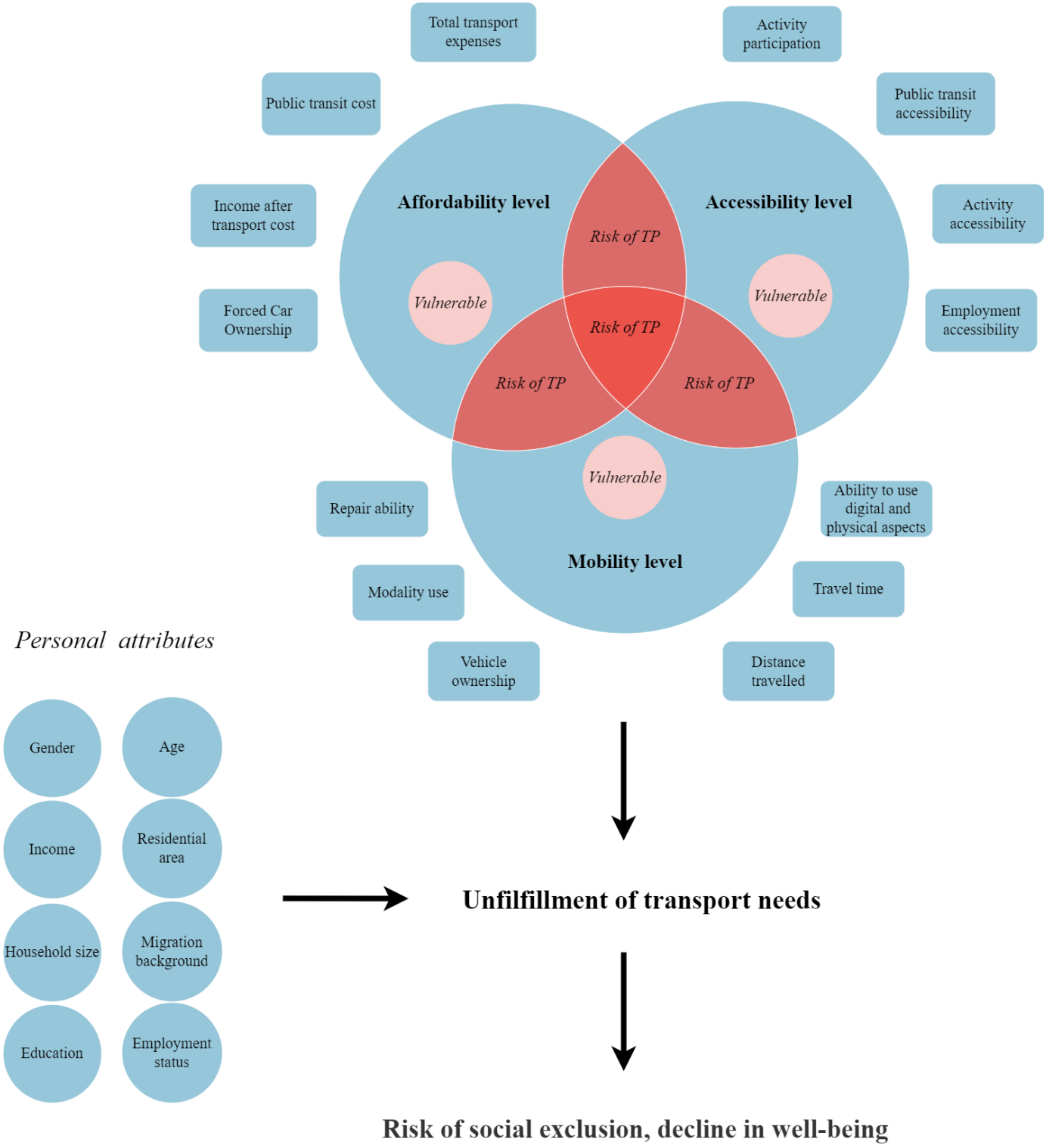
Appendix

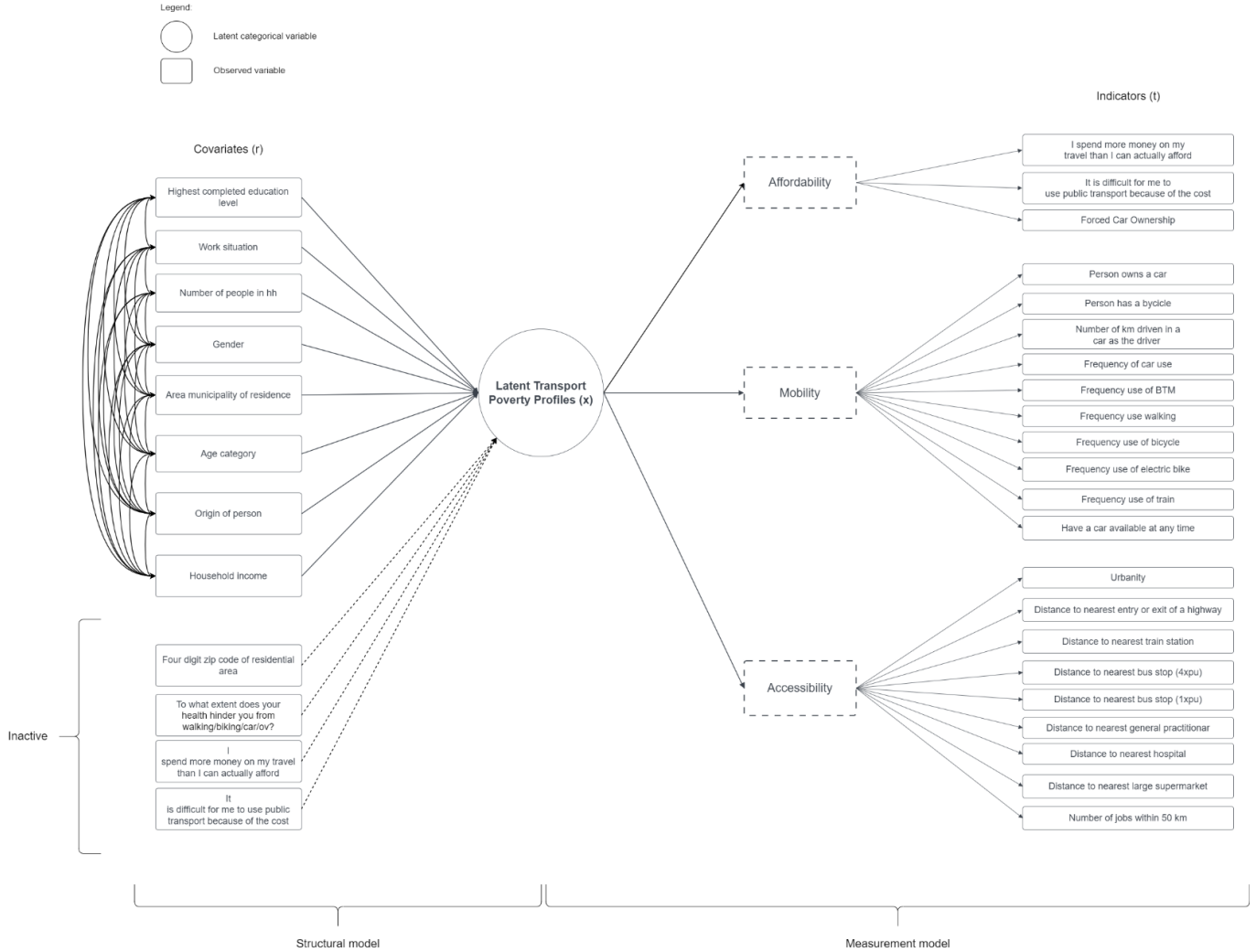
Appendix A: Conceptual model of Transport Poverty Risk



Appendix B: Correlation analysis output

	Affordability overall mobility	Affordability public transport	ForcedCarOwnership	Urbanity	Distance to tramstop	Distance to busstop 4xpu	Distance to busstop 1xpu	Distace to metrostop	Distance to busstop 2xpu	Distance to busstop l1xpu	Distance to general practitionar	Distance to hospital	Distance to supermarket	Frequency train use	Frequency bus, tram and metro use
Affordability overall mobility		0,572	0,630												
Affordability public transport	0,572		0,621												
ForcedCarOwnership	0,630	0,621													
Urbanity						0,584	0,513		0,575	0,503	0,539	0,659	0,525		
Distance to tramstop								0,962							
Distance to busstop 4xpu				0,584			0,621		0,746	0,591	0,509	0,523	0,530		
Distance to busstop 1xpu				0,513		0,621			0,844	0,946	0,501				
Distace to metrostop					0,962										
Distance to busstop 2xpu				0,575		0,746	0,844			0,792	0,516	0,510	0,521		
Distance to busstop l1xpu				0,503		0,591	0,946		0,792						
Distance to general practitionar				0,539		0,509	0,501		0,516			0,520	0,769		
Distance to hospital				0,659		0,523			0,510		0,520		0,517		
Distance to supermarket				0,525		0,530			0,521		0,769	0,517			
Frequency auto use															
Frequency train use															0,658
Frequency bus, tram and metro use														0,658	
Auto availability															

Appendix C: Latent Cluster Analysis Model



Appendix D: Extensive MPN indicator specification

Transport	Indicator description	Measurement level	Unit	Data reference
Mobility	Person has a car	Nominal	0=No, 1=Yes, 2=not any vehicle	PAUTO
	Person has a bicycle	Nominal	0=No, 1=Yes	PBICYCLE
	Frequency of car use (as driver or passenger)	Ordinal	1=most, 6=never	GEBRUIK_AUTO_w5
	Frequency of bicycle use	Ordinal	1=most, 6=never	GEBRUIK_FIETS_w5
	Number of km driven in a car as the driver	Ordinal	1=lowest, 9=highest	AUTOKM_BESTUURDER
	Frequency use of electric bicycle	Ordinal	1=most, 6=never	GEBRUIK_EBIKE
	Have a car available at any time	Nominal	4 categories	BESCHIK_AUTO
	Frequency use of bus, tram and metro	Ordinal	1=most, 6=never	GEBRUIK_BTM_w5
	Frequency of train use	Ordinal	1=most, 6=never	GEBRUIK_TREIN_w5
	Frequency walk	Ordinal	1=most, 6=never	GEBRUIK_LOPEN_w5
	To what extent does your health hinder you from walking?	Ordinal	1=very much, 4=not at all	GEZOND_BELEMMER1
	To what extent does your health hinder you from cycling?	Ordinal	1=very much, 4=not at all	GEZOND_BELEMMER2
	To what extent does your health hinder you from driving?	Ordinal	1=very much, 4=not at all	GEZOND_BELEMMER3
	To what extent does your health hinder you when travelling with ov?	Ordinal	1=very much, 4=not at all	GEZOND_BELEMMER4
Accessibility	Urbanity (municipal level)	Ordinal	1= very higly urbanized, 5= non-urbanized	STED_GM
	Straight line distance between nearest entry or exit of a highway and residential location	Ratio	#km	wlokatie_opafrit

Straight line distance between nearest station and residential location	Ratio	#m	wlokatie_station
Straight line distance between nearest metro or express tram stop and residential location	Ratio	#m	wlokatie_metrosneltramhalte
Straight line distance between nearest tram stop and residential location	Ratio	#m	wlokatie_tramhalte
Straight line distance between nearest bus stop with at least 4 times per hour a bus and residential location	Ratio	#m	wlokatie_bushalte4xpu
Straight line distance between nearest bus stop with at least 2 times per hour a bus and residential location	Ratio	#m	wlokatie_bushalte2xpu
Straight line distance between nearest bus stop with at least 1 time per hour a bus and residential location	Ratio	#m	wlokatie_bushalte1xpu
Straight line distance between nearest bus stop with at less than 1 time per hour a bus and residential location	Ratio	#m	wlokatie_bushaltekl1xpu
My neighbourhood is easily accessible by car	Ordinal	1=strongly disagree, 5=strongly agree	STELLING_AUTO
My neighborhood is easily accessible by bicycle	Ordinal	1=strongly disagree, 5=strongly agree	STELLING_FIETS_w5
My neighbourhood is easily accessible by Public Transport	Ordinal	1=strongly disagree, 5=strongly agree	STELLING_OV
Distance to the nearest general practitioner	Ratio	#km	Afstand_Huisarts
Distance to the nearest hospital	Ratio	#km	Afstand_Zieken
Distance to the nearest large supermarket	Ratio	#km	Afstand_GrSupermarkt
Number of jobs available within 50 km	Ratio	#jobs	Aantalbanen_50km

Affordability	I spend more money on my travel than I can actually afford	Ordinal	1=completely disagree, 5=completely agree	Bet_mobiliteit_S2
	It is difficult for me to use public transport because of the cost	Ordinal	1=completely disagree, 5=completely agree	Bet_ov_S1
	Actually, I can hardly afford the cost of car use	Ordinal	1=completely disagree, 5=completely agree	Auto_stelling_S1
	Car ownership is a necessity, not a free choice	Ordinal	1=completely disagree, 5=completely agree	Auto_stelling_S4

Appendix E: Extensive MPN socio-demographics specification

Socio-demographic attribute	Measurement level	Units	Data reference
Highest completed education level	Ordinal	1=lowest, 8=highest	OPLEIDING
Work situation person (most applicable)	Nominal	9 categories	WERKSITUATIE_MEEST_w5
Number of people in household	Interval	#persons	HHPERS
Gender	Nominal	1=Man, 2=Woman	GENDER
COROP area municipality of residence	Nominal	40 areas	COROP
Age	Interval	Number of years	LEEFTIJD
Origin of person	Nominal	1=Dutch, 2=Europe, 3=not Europe	HERKOMST_w5
Household income	Ordinal	1=least, 27=most	HHBRUTOINK1_w5
I can easily carry out my desired daily activities	*Ordinal*	*1=completely disagree, 5=completely agree*	*FINALtevredenheid_S1*
All in all, I am satisfied with how I can get around	*Ordinal*	*1=completely disagree, 5=completely agree*	*FINALtevredenheid_S2*

Appendix F: Complete LCA results

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Cluster9	Cluster10	Cluster11
Cluster Size	0,1754	0,1672	0,0973	0,0952	0,0902	0,0858	0,0824	0,0764	0,0503	0,0474	0,0324
Indicators											
Affordability overall mobility											
Completely disagree	0,34	0,3802	0,2153	0,3051	0,3656	0,2999	0,2918	0,2519	0,2077	0,2049	0,2199
Disagree	0,4736	0,4661	0,451	0,4752	0,4694	0,475	0,4744	0,4666	0,4467	0,445	0,4535
Neutral	0,1307	0,1132	0,1873	0,1467	0,1195	0,1491	0,1528	0,1712	0,1903	0,1915	0,1853
Agree	0,0409	0,0312	0,0882	0,0514	0,0345	0,0531	0,0559	0,0713	0,092	0,0935	0,0859
Completely agree	0,0083	0,0055	0,0268	0,0116	0,0064	0,0122	0,0132	0,0191	0,0287	0,0294	0,0257
Doesn't know/won't say	0,0064	0,0038	0,0314	0,0101	0,0046	0,0108	0,012	0,0198	0,0345	0,0357	0,0296
Mean	1,9232	1,8273	2,3545	2,0196	1,8605	2,0352	2,0601	2,1986	2,3908	2,4046	2,3328
Affordability public transport											
Completely disagree	0,3641	0,4646	0,2291	0,332	0,3812	0,3697	0,2824	0,2998	0,1723	0,2256	0,2873
Disagree	0,3759	0,3673	0,3349	0,3722	0,3765	0,3762	0,3594	0,365	0,2946	0,3329	0,3611
Neutral	0,154	0,1152	0,1942	0,1655	0,1475	0,1518	0,1815	0,1762	0,1998	0,1949	0,18
Agree	0,0619	0,0355	0,1106	0,0723	0,0567	0,0602	0,09	0,0835	0,133	0,112	0,0881
Completely agree	0,0256	0,0112	0,0649	0,0325	0,0225	0,0246	0,0459	0,0408	0,0913	0,0663	0,0444
Doesn't know/won't say	0,0185	0,0062	0,0663	0,0255	0,0155	0,0175	0,0409	0,0347	0,109	0,0683	0,039
Mean	2,0647	1,7801	2,6459	2,1774	2,0092	2,046	2,3803	2,3045	3,0036	2,6654	2,3585
FORCEDCAROWNERSHIP											
Mean	-0,083	-0,2857	0,3927	0,0342	-0,2993	-0,027	0,0542	0,9313	0,4925	0,4391	0,9762
Urbanity											
Very strong urbanity	0,0649	0,4871	0,0911	0,6148	0,0085	0,1823	0,0098	0,6341	0,0106	0,0012	0,0657
Strong urbanity	0,3676	0,4521	0,4254	0,3569	0,1161	0,5248	0,1264	0,341	0,1331	0,0317	0,3696
Medium urbanity	0,2565	0,0517	0,2449	0,0255	0,1945	0,1862	0,2016	0,0226	0,2059	0,1019	0,2563
Low urbanity	0,2659	0,0088	0,2094	0,0027	0,484	0,0982	0,4774	0,0022	0,4729	0,4862	0,264
No urbanity	0,0451	0,0002	0,0293	0	0,1968	0,0085	0,1848	0	0,1776	0,3789	0,0444
Mean	2,8587	1,583	2,6604	1,4163	3,7445	2,2256	3,701	1,393	3,6737	4,2098	2,8518
Distance highway											
Mean	3059,65	2155,76	3466,46	2192,07	7025,53	1677,21	3755,72	2017,72	9907,45	10430,2	3815,18
Distance train station											
Mean	3715,16	1855,19	5088,48	2032,34	6072,61	1649,48	4584,71	1401,86	7978,49	6947,16	3247,71
Distance busstop 4xph											
Mean	927,889	351,72	514,97	268,658	3517,21	1083,74	2759,95	329,237	795,177	6543,79	1500,16
Distance busstop 1xph											
Mean	316,166	217,994	268,735	215,887	470,371	365,842	442,41	225,653	352,618	1158,17	419,344
Number of jobs 50 km											
Mean	1441,08	1725,77	1488,43	1730,87	691,945	1284,71	1383,2	1839,03	554,548	526,823	1327,64
Distance gen. prac.											
Mean	1,2454	0,8154	1,1045	0,8154	2,0307	1,2198	1,787	0,7855	1,335	2,9783	1,2303
Distance hospital											
Mean	7,911	3,2956	7,4177	3,3498	12,0349	4,6003	10,7826	2,7533	12,2725	14,6934	7,838
Distance supermarket											
Mean	1,1469	0,7546	0,9568	0,7631	1,8023	1,096	1,7329	0,6883	1,1433	2,4672	1,1909
Car owbership											
No	0,0271	0,1118	0,2642	0,0362	0,051	0,0983	0,0793	0,8629	0,0921	0,1386	0,7592
Yes	0,9702	0,8757	0,6843	0,9592	0,9452	0,8987	0,8925	0,0098	0,8811	0,8258	0,2011
No drivers licence	0,0027	0,0125	0,0515	0,0045	0,0038	0,003	0,0281	0,1273	0,0268	0,0357	0,0397

Number of km as car driver											
Less than 500 km	0,0603	0,0841	0,1619	0,1295	0,039	0,1259	0,1007	0,6546	0,1462	0,0928	0,3915
500 - 2.500 km	0,1281	0,1605	0,2409	0,2114	0,094	0,2079	0,1807	0,2717	0,2273	0,1714	0,3372
2.500 - 5.000 km	0,1376	0,155	0,1812	0,1746	0,1146	0,1735	0,1639	0,0571	0,1786	0,16	0,1469
5.000 - 7.500 km	0,1549	0,157	0,143	0,1512	0,1466	0,1519	0,1559	0,0126	0,1472	0,1566	0,0671
7.500 - 10.000 km	0,1942	0,177	0,1257	0,1458	0,2089	0,1481	0,1652	0,0031	0,1352	0,1708	0,0341
10.000 km or more	0,3249	0,2663	0,1473	0,1875	0,3969	0,1926	0,2335	0,001	0,1655	0,2484	0,0232
Mean	4,2691	3,9813	3,2716	3,5347	4,5831	3,5663	3,8047	1,4409	3,3943	3,8862	2,0846
Car availability											
Yes, whenever I want	0,7836	0,6964	0,568	0,7706	0,8111	0,7058	0,7019	0,005	0,7118	0,7218	0,108
No, I have to coordinate that with people	0,1822	0,2252	0,1298	0,161	0,1596	0,198	0,1863	0,0345	0,1452	0,1288	0,2829
No, but I can sometimes use	0,0095	0,0287	0,0196	0,0055	0,0081	0,0061	0,0139	0,1624	0,0211	0,005	0,1577
No, (almost) never	0,0067	0,0089	0,0498	0,0228	0	0,0089	0,0159	0,1957	0,0452	0,0198	0,0706
Person does not have a car licence	0,018	0,0408	0,2328	0,0401	0,0211	0,0811	0,0821	0,6025	0,0767	0,1246	0,3807
Bicycle ownership											
No	0,1635	0,183	0,3196	0,2709	0,1678	0,1604	0,199	0,2067	0,2327	0,3195	0,1067
Yes	0,8365	0,817	0,6804	0,7291	0,8322	0,8396	0,801	0,7933	0,7673	0,6805	0,8933
Car use											
4 or more days per week	0,4725	0,356	0,2345	0,3617	0,5981	0,33	0,3411	0,0546	0,3237	0,3517	0,1462
1 - 3 days per week	0,4268	0,461	0,4344	0,4604	0,3526	0,4618	0,4618	0,1905	0,4615	0,4613	0,3542
1 - 3 days per month	0,0813	0,126	0,1698	0,1237	0,0439	0,1363	0,1319	0,1403	0,1388	0,1277	0,1811
6 -11 days per year	0,0109	0,0242	0,0467	0,0234	0,0038	0,0283	0,0265	0,0727	0,0294	0,0249	0,0651
1 - 5 days per year	0,004	0,0127	0,0351	0,0121	0,0009	0,0161	0,0146	0,1029	0,017	0,0132	0,064
(Almost) never	0,0044	0,0201	0,0794	0,0188	0,0007	0,0275	0,0241	0,4389	0,0296	0,0212	0,1895
Mean	1,6603	1,9371	2,4519	1,9199	1,4588	2,0211	1,9839	4,2955	2,0431	1,9501	3,115
Train use											
4 or more days per week	0,0071	0,0245	0,0019	0,0043	0,0044	0,0088	0,0017	0,0743	0,0002	0,0022	0,2612
1 - 3 days per week	0,0331	0,0838	0,0119	0,0225	0,0227	0,0388	0,0109	0,1829	0,0024	0,0132	0,3608
1 - 3 days per month	0,0525	0,0977	0,0256	0,04	0,0404	0,0586	0,0239	0,1533	0,008	0,0274	0,1699
6 -11 days per year	0,095	0,1299	0,0624	0,0815	0,0819	0,1009	0,0599	0,1467	0,0303	0,0652	0,0913
1 - 5 days per year	0,2401	0,2413	0,213	0,2315	0,2317	0,2426	0,2099	0,1959	0,1602	0,2161	0,0684
(Almost) never	0,5721	0,4228	0,6852	0,6203	0,619	0,5502	0,6937	0,2468	0,7989	0,676	0,0484
Mean	5,2442	4,7483	5,5282	5,3741	5,3709	5,1804	5,5466	3,9473	5,7443	5,5077	2,4903
Bustrammetro use											
4 or more days per week	0,0052	0,0219	0,0067	0,0132	0,0016	0,0068	0,001	0,0972	0,0006	0,0016	0,162
1 - 3 days per week	0,0237	0,0696	0,0285	0,0479	0,0093	0,0288	0,0065	0,1941	0,0043	0,0095	0,2599
1 - 3 days per month	0,0622	0,1283	0,0706	0,1005	0,032	0,0712	0,0249	0,2248	0,0183	0,0325	0,2418
6 -11 days per year	0,0972	0,1408	0,1043	0,1257	0,0657	0,1048	0,0562	0,155	0,0464	0,0663	0,134
1 - 5 days per year	0,1948	0,1983	0,1978	0,2017	0,1729	0,1979	0,1632	0,1371	0,1513	0,1735	0,0953
(Almost) never	0,6169	0,4411	0,5922	0,511	0,7186	0,5905	0,7481	0,1917	0,7792	0,7166	0,107
Mean	5,3032	4,7474	5,2347	4,9877	5,5547	5,2299	5,6185	3,6157	5,6811	5,5502	3,0618
Bicycle use											
4 or more days per week	0,2314	0,2861	0,0824	0,1225	0,2327	0,1853	0,108	0,271	0,1794	0,1057	0,5768
1 - 3 days per week	0,2101	0,2374	0,1033	0,1376	0,2108	0,1826	0,1257	0,2305	0,1787	0,1238	0,2812
1 - 3 days per month	0,099	0,1022	0,0671	0,0802	0,0991	0,0933	0,076	0,1017	0,0924	0,0752	0,0712
6 -11 days per year	0,0541	0,0511	0,0506	0,0542	0,0541	0,0553	0,0532	0,052	0,0554	0,053	0,0209
1 - 5 days per year	0,0501	0,0432	0,0646	0,062	0,0499	0,0556	0,0631	0,0451	0,0563	0,0633	0,0104
(Almost) never	0,3552	0,28	0,632	0,5435	0,3533	0,4278	0,5739	0,2997	0,4378	0,579	0,0395
Mean	3,5469	3,1677	4,8077	4,4261	3,5378	3,897	4,5594	3,2689	3,944	4,5814	1,7254
Ebike use											
4 or more days per week	0,1613	0,1257	0,1844	0,1813	0,1501	0,2056	0,2027	0,0921	0,1873	0,1744	0,0369
1 - 3 days per week	0,1461	0,1223	0,1604	0,1585	0,1389	0,1726	0,171	0,0972	0,1621	0,1543	0,0483
1 - 3 days per month	0,0567	0,0509	0,0597	0,0594	0,055	0,0621	0,0618	0,0439	0,0601	0,0585	0,0271

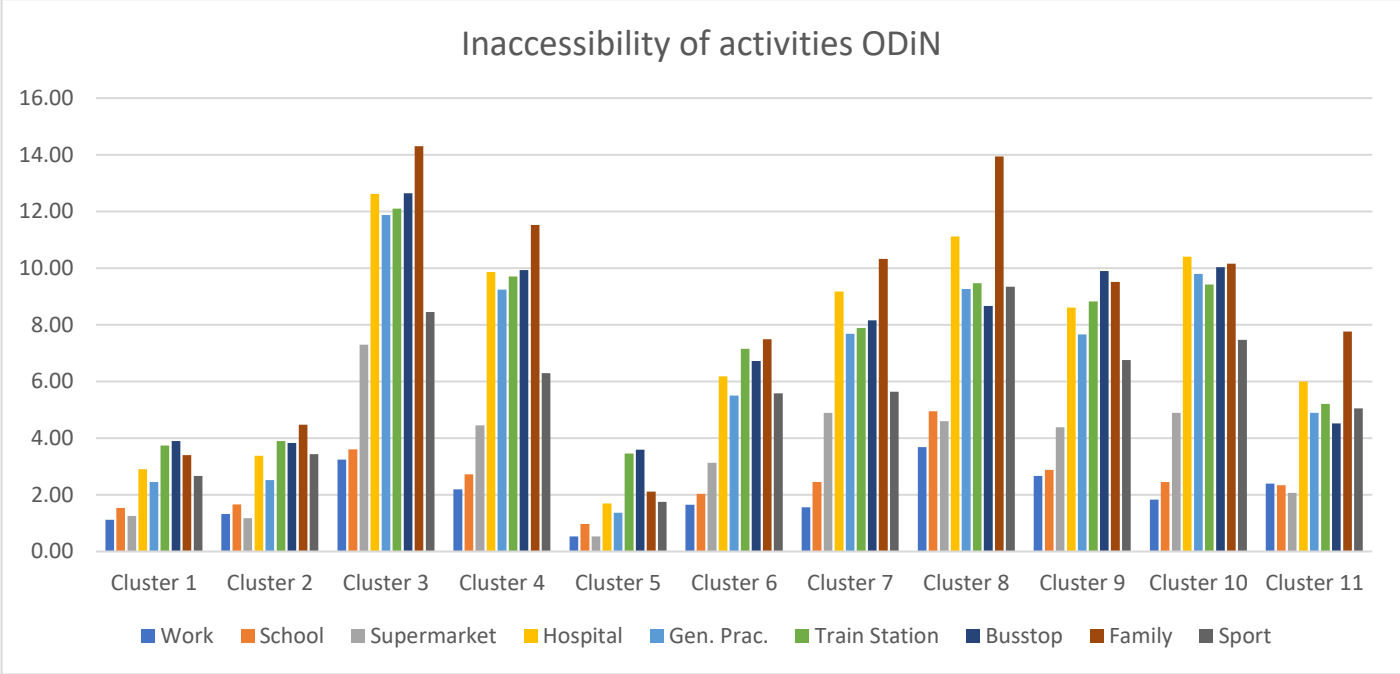
6 -11 days per year	0,0276	0,0266	0,0279	0,0279	0,0274	0,028	0,028	0,0249	0,0279	0,0278	0,0191
1 - 5 days per year	0,0207	0,0214	0,0201	0,0202	0,0209	0,0194	0,0195	0,0218	0,02	0,0203	0,0206
(Almost) never	0,5876	0,6531	0,5476	0,5528	0,6077	0,5122	0,517	0,7201	0,5425	0,5646	0,848
Mean	4,3629	4,6551	4,1817	4,2057	4,4534	4,0198	4,0419	4,9472	4,1588	4,259	5,4824
Walking use											
4 or more days per week	0,5402	0,5643	0,4318	0,478	0,484	0,5383	0,4445	0,551	0,4661	0,4459	0,6585
1 - 3 days per week	0,2792	0,2775	0,2704	0,2773	0,2778	0,2793	0,2728	0,2786	0,2759	0,273	0,256
1 - 3 days per month	0,0693	0,0656	0,0814	0,0773	0,0766	0,0696	0,0804	0,0677	0,0785	0,0803	0,0478
6 -11 days per year	0,0176	0,0158	0,025	0,022	0,0216	0,0177	0,0242	0,0168	0,0228	0,0241	0,0091
1 - 5 days per year	0,0119	0,0102	0,0205	0,0167	0,0162	0,012	0,0194	0,0111	0,0176	0,0193	0,0046
(Almost) never	0,0818	0,0666	0,1709	0,1288	0,1238	0,0831	0,1587	0,0748	0,1391	0,1574	0,024
Mean	1,9272	1,8301	2,4447	2,2085	2,1797	1,9351	2,3772	1,8827	2,2672	2,37	1,5174
Mobility health hinderance											
Mean	0,6404	0,6406	-0,8727	-0,5737	0,6405	-0,3418	-0,6204	-0,3898	-0,4876	-0,3378	0,4051
Covariates											
Gender											
Man	0,5223	0,5307	0,3469	0,4684	0,5307	0,4311	0,4208	0,3619	0,4798	0,4399	0,3821
Woman	0,4777	0,4693	0,6531	0,5316	0,4693	0,5689	0,5792	0,6381	0,5202	0,5601	0,6179
Age											
1 18	0,213	0,2659	0,0964	0,1291	0,2363	0,1241	0,1069	0,2949	0,1374	0,1761	0,7446
19 - 28	0,2524	0,226	0,1204	0,1607	0,2409	0,1672	0,1633	0,1582	0,1161	0,163	0,1285
29 - 41	0,2447	0,2388	0,1778	0,1787	0,2402	0,2014	0,2053	0,1556	0,2036	0,2161	0,0674
42 - 52	0,1875	0,1599	0,2447	0,2328	0,1905	0,2561	0,2669	0,1494	0,2899	0,2432	0,044
53 - 79	0,1023	0,1094	0,3608	0,2987	0,0921	0,2513	0,2575	0,2419	0,253	0,2016	0,0156
Mean	48,6421	47,4258	60,4687	57,7395	48,1077	56,7024	57,5667	50,251	57,2448	53,8098	29,5573
Country of origin											
Native	0,9136	0,8939	0,9341	0,8856	0,942	0,9245	0,949	0,8703	0,9326	0,9524	0,8821
(Other) Europe	0,0331	0,0342	0,029	0,038	0,0263	0,0419	0,0244	0,0552	0,0348	0,0177	0,0628
Other world (not Europe)	0,0325	0,0535	0,0247	0,0516	0,0098	0,0232	0,0123	0,0502	0,0326	0,0149	0,049
Unkown	0,0207	0,0183	0,0122	0,0248	0,0219	0,0104	0,0143	0,0242	0	0,015	0,0061
COROP											
Oost-Groningen	0,0089	0	0	0	0,0371	0,0046	0,0095	0	0,06	0,0691	0
Delfzijl en omgeving	0	0	0	0	0,0057	0	0	0	0,0359	0,0347	0
Overig Groningen	0,0114	0,0338	0,0024	0,0898	0,0574	0,0172	0,0114	0,0501	0,0285	0,0867	0,0072
Noord-Friesland	0,0037	0,0084	0,0031	0,0076	0,0499	0	0,0055	0,0061	0,0655	0,0316	0
Zuidwest-Friesland	0,0119	0	0,0071	0	0,0264	0,0172	0,0063	0	0,0304	0,0088	0
Zuidoost-Friesland	0,0071	0	0,0081	0	0,0279	0,0181	0,0203	0	0,0632	0	0,0145
Noord-Drenthe	0,0209	0,0014	0,0026	0	0,0202	0,0334	0,0104	0,0061	0,0084	0,0049	0,019
Zuidoost-Drenthe	0,0124	0	0,0046	0	0,0471	0,005	0,0081	0	0,0243	0,1261	0
Zuidwest-Drenthe	0,0015	0,0013	0	0	0,0139	0,0642	0,0061	0,0005	0	0,0278	0,0145
Noord-Overijssel	0,006	0,0176	0,0118	0,0208	0,0812	0	0,0053	0,0131	0,0822	0,043	0,0254
Zuidwest-Overijssel	0	0,0195	0,0025	0,0148	0,0207	0	0,0057	0,021	0	0	0,0079

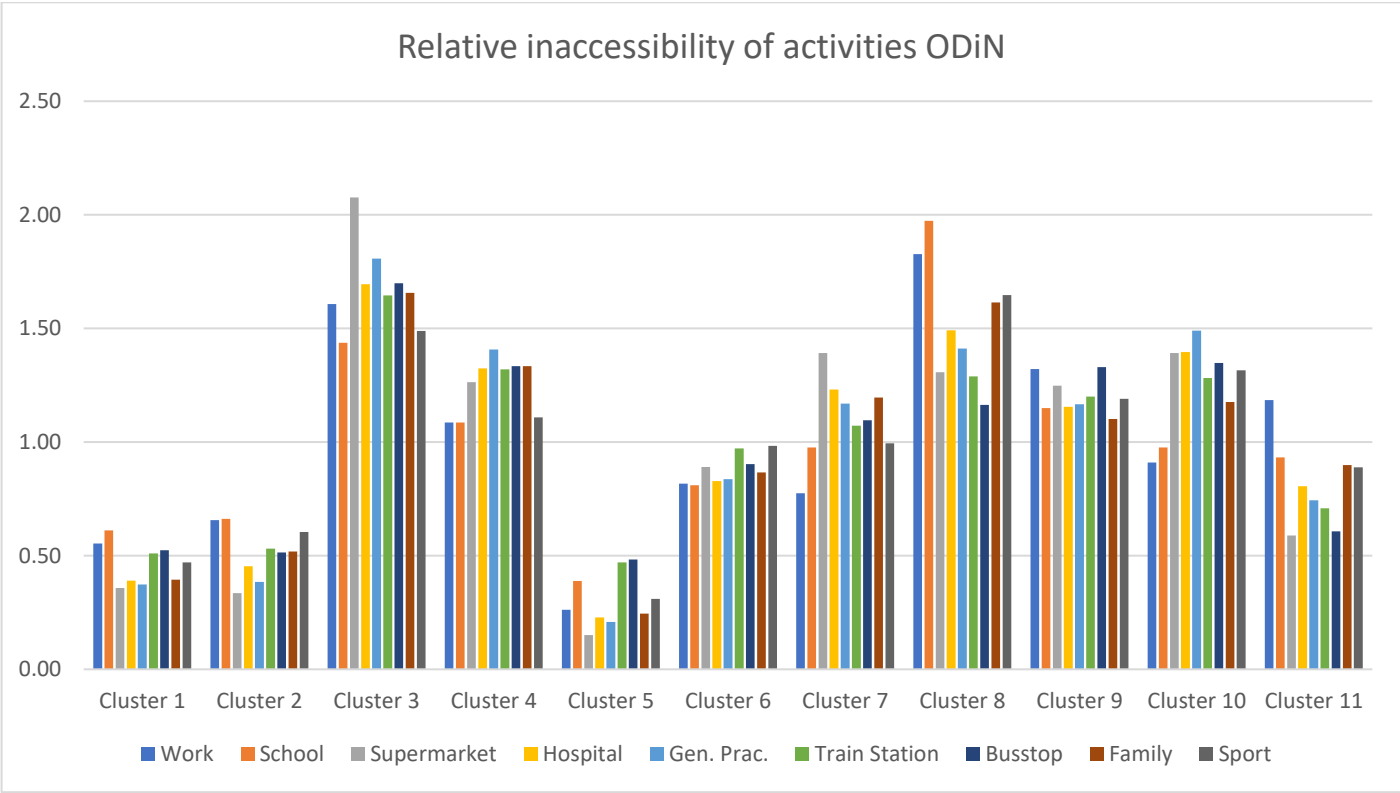
Twente	0,0413	0,0316	0,0333	0,027	0,0422	0,0161	0,0156	0,0191	0,1004	0,0162	0,0404
Veluwe	0,0364	0,0434	0,0288	0,026	0,0225	0,0318	0,0651	0,0144	0,0099	0,0096	0,0424
Achterhoek	0,0083	0,0027	0,0079	0,005	0,0494	0	0,0294	0,0031	0,1444	0,0682	0,0581
Arnhem/Nijmegen	0,0623	0,0315	0,0792	0,0322	0,0108	0,0552	0,0437	0,0606	0	0,0361	0,0393
Zuidwest-Gelderland	0,0239	0	0,0086	0	0,0216	0,0216	0,0432	0	0	0	0,0144
Utrecht	0,1141	0,0948	0,0734	0,0689	0	0,0832	0,0965	0,0887	0	0,0197	0,0871
Kop van Noord-Holland	0,0118	0,0124	0,0008	0	0,0866	0,014	0,03	0,003	0,0731	0,1567	0,0087
Alkmaar en omgeving	0,0147	0,0097	0,0268	0,0028	0,0123	0,0044	0,007	0,0091	0	0	0,0279
IJmond	0,0066	0,0144	0,0127	0,0114	0	0,0223	0	0,0236	0	0	0,0133
Agglomeratie Haarlem	0,0024	0,0309	0,0212	0,0155	0	0	0,0028	0,015	0	0	0
Zaanstreek	0,0242	0,0135	0	0,0053	0	0,0223	0	0,0092	0	0	0,0059
Groot-Amsterdam	0,0221	0,1009	0,0502	0,1283	0	0,0092	0,006	0,1472	0	0,0048	0,0163
Het Gooi en Vechtstreek	0,0069	0,0123	0,0091	0,0259	0	0,0079	0,0043	0,0157	0	0,0148	0
Agglomeratie Leiden en Bollenstreek	0,0233	0,0515	0,0283	0,0355	0	0,0114	0,0201	0,0301	0	0	0,009
Agglomeratie 's-Gravenhage	0,0278	0,0547	0,0167	0,0917	0	0,1102	0,0058	0,0985	0	0	0,0707
Delft en Westland	0,0226	0,0179	0,0179	0,0048	0	0,015	0,0032	0,0339	0	0	0,0144
Oost-Zuid-Holland	0,0304	0,0204	0,0124	0,0074	0	0,0408	0,0652	0,0104	0	0,0049	0
Groot-Rijnmond	0,1203	0,0947	0,2122	0,1307	0,0118	0,058	0,0427	0,1088	0,0464	0,005	0,0837
Zuidoost-Zuid-Holland	0,011	0,0577	0	0,0452	0,003	0,0231	0,0326	0,0318	0	0	0,0247
Zeeuwsch-Vlaanderen	0	0	0	0	0,0219	0	0	0	0,0442	0,0394	0
Overig Zeeland	0,0074	0,0052	0	0,0017	0,0517	0,0662	0,0513	0,0031	0,03	0,0548	0,0147
West-Noord-Brabant	0,0538	0,023	0,0658	0,0186	0,041	0,0315	0,0615	0,0321	0,0147	0,0068	0,014
Midden-Noord-Brabant	0,038	0,0537	0,0484	0,0573	0,0026	0,0035	0,0382	0,0389	0	0,0049	0
Noordoost-Noord-Brabant	0,0558	0,006	0,0552	0,0092	0,0491	0,0083	0,071	0,0207	0	0,0153	0,0651
Zuidoost-Noord-Brabant	0,0566	0,0394	0,0385	0,0402	0,0575	0,0112	0,0317	0,025	0,082	0,041	0,1237
Noord-Limburg	0,0074	0,0138	0,0128	0	0,0462	0,0686	0,0332	0,0042	0,0266	0,005	0,0165
Midden-Limburg	0,018	0,0042	0	0	0,0423	0,0542	0,0469	0,003	0,0092	0,02	0,048
Zuid-Limburg	0,0652	0,0242	0,0896	0,019	0,005	0,0356	0,0548	0,0124	0,0001	0	0,0584
Flevoland	0,0036	0,0535	0,0077	0,0576	0,0352	0,0145	0,0099	0,0413	0,0205	0,0441	0,0148
Household size											
1	0,1638	0,2395	0,3067	0,3004	0,135	0,2047	0,19	0,6317	0,218	0,2246	0,2626
2	0,364	0,3842	0,4587	0,4988	0,407	0,5067	0,5076	0,2381	0,487	0,4339	0,1253
3	0,1593	0,1457	0,0969	0,1037	0,1581	0,141	0,0933	0,0549	0,1093	0,1281	0,1877

4 8	0,3128	0,2306	0,1354	0,0971	0,2926	0,1449	0,2033	0,0754	0,1856	0,2134	0,4244
.	0,0002	0	0,0023	0	0,0073	0,0027	0,0057	0	0,0002	0	0
Mean	2,7138	2,443	2,0934	2,0372	2,7849	2,2608	2,4129	1,6155	2,3055	2,477	2,9338
Household income											
1 12	0,0767	0,0914	0,2849	0,1929	0,0858	0,1334	0,1862	0,3905	0,3033	0,2409	0,2422
13 - 14	0,1409	0,1675	0,2371	0,2328	0,1502	0,2562	0,2078	0,2134	0,1842	0,2292	0,0929
15 - 16	0,3606	0,3114	0,2407	0,305	0,3349	0,262	0,3094	0,1675	0,2104	0,2146	0,2807
17 - 18	0,2322	0,2135	0,0755	0,1593	0,203	0,2041	0,1265	0,0788	0,0987	0,0691	0,1528
19 - 26	0,1844	0,2162	0,1618	0,1076	0,226	0,1389	0,1673	0,1498	0,1942	0,2462	0,2314
.	0,0053	0	0	0,0025	0,0001	0,0054	0,0028	0	0,0092	0	0
Mean	17,1819	17,272	15,2079	15,5038	17,8442	16,367	16,2693	14,0683	15,923	16,7673	16,2498
Education level											
0	0,02	0,0269	0,0548	0,0295	0,0382	0,0158	0,0278	0,0706	0,0464	0,0742	0,1676
1	0,0823	0,0693	0,1755	0,1273	0,0853	0,16	0,1507	0,1063	0,2294	0,145	0,0503
2	0,073	0,0822	0,1694	0,1469	0,0681	0,0924	0,1113	0,139	0,113	0,145	0,1441
3	0,3949	0,3477	0,3917	0,383	0,4065	0,3792	0,3997	0,3402	0,3768	0,488	0,4607
4	0,4285	0,474	0,2086	0,3134	0,4019	0,3526	0,3105	0,3378	0,2297	0,1477	0,1773
9	0,0013	0	0	0	0	0	0	0,0061	0,0046	0	0
Work situation											
Paid employment	0,776	0,7312	0,2552	0,4427	0,7621	0,4833	0,4373	0,3691	0,3941	0,4713	0,461
Unable to work	0,0035	0,0105	0,131	0,0809	0,0086	0,0834	0,111	0,1097	0,1287	0,1209	0,0076
Unemployed	0,0025	0,0101	0,0422	0,01	0,0037	0,0213	0,0075	0,0518	0,0187	0,017	0,0491
Retired or VUT	0,1478	0,159	0,3733	0,3775	0,1453	0,3415	0,3011	0,2763	0,3159	0,2304	0,0395
Student	0,0162	0,0364	0,0137	0	0,0269	0	0,012	0,1192	0,0159	0,0261	0,4155
Housewoman/houseman	0,0412	0,0305	0,1268	0,0561	0,0314	0,0474	0,0923	0,0345	0,0723	0,0862	0,0068
voluntary work	0,01	0,0141	0,0411	0,0267	0,016	0,0204	0,0267	0,0251	0,0428	0,0198	0,0133
Unknown	0	0,0028	0,0095	0	0	0	0,0029	0,0031	0	0,0098	0
Other	0,0028	0,0055	0,0073	0,0063	0,0058	0,0027	0,0092	0,0111	0,0115	0,0186	0,0072
Satisfaction overal mobility											
1 3	0,0543	0,0437	0,1365	0,0959	0,0268	0,0752	0,0774	0,1626	0,1495	0,0782	0,1605
4	0,2969	0,3351	0,3034	0,3149	0,2767	0,324	0,2857	0,3451	0,2506	0,2827	0,3749
5 6	0,2016	0,2366	0,0718	0,1712	0,1626	0,1962	0,1491	0,1401	0,0992	0,1105	0,131
.	0,4471	0,3846	0,4882	0,4179	0,5339	0,4046	0,4877	0,3521	0,5006	0,5286	0,3336
Mean	4,2482	4,2946	3,7668	4,0776	4,2625	4,1642	4,0781	3,854	3,8037	4,0548	3,9138
Satisfaction daily activities											
1 3	0,0505	0,0241	0,1479	0,1096	0,0244	0,0808	0,0926	0,1366	0,1265	0,0729	0,1002
4	0,2833	0,3383	0,2915	0,3056	0,2677	0,3143	0,2814	0,3671	0,2596	0,2664	0,4209
5 6	0,2191	0,2529	0,0724	0,1669	0,1739	0,2003	0,1382	0,1442	0,1132	0,132	0,1453
.	0,4471	0,3846	0,4882	0,4179	0,5339	0,4046	0,4877	0,3521	0,5006	0,5286	0,3336
Mean	4,3024	4,3635	3,7233	4,001	4,3079	4,1465	4,0159	3,9034	3,9171	4,1144	4,045
Affordability car											
1	0,1631	0,2115	0,0409	0,1264	0,1494	0,1389	0,106	0,0087	0,0561	0,0464	0,0498
2	0,234	0,26	0,1633	0,2501	0,2323	0,2608	0,1736	0,0078	0,1599	0,2097	0,0622
3 6	0,1353	0,0885	0,1505	0,1476	0,0676	0,1208	0,1588	0,0182	0,188	0,1562	0,19
.	0,4676	0,44	0,6453	0,4759	0,5507	0,4795	0,5616	0,9652	0,596	0,5877	0,6981
Mean	2,0714	1,8081	2,5914	2,1853	1,864	2,0922	2,28	3,0867	2,639	2,5987	3,1202
Neccessity car											
1	0,1902	0,2142	0,0616	0,1297	0,1619	0,1359	0,1375	0,0088	0,0861	0,0617	0,0451
2	0,2171	0,24	0,1609	0,2612	0,2294	0,2596	0,1894	0,0091	0,1423	0,1924	0,0933
3 6	0,1251	0,1058	0,1322	0,1333	0,0579	0,125	0,1114	0,0169	0,1756	0,1582	0,1635
.	0,4676	0,44	0,6453	0,4759	0,5507	0,4795	0,5616	0,9652	0,596	0,5877	0,6981
Mean	2,0602	1,9216	2,4922	2,1821	1,8325	2,155	2,1214	3,0825	2,6494	2,5814	3,14
Health hinderance car											
Very	0	0	0,2081	0,1207	0	0,1069	0,166	0,138	0,108	0,0973	0,0072

Somewhat	0	0	0,38	0,3375	0	0,2755	0,3136	0,2383	0,3599	0,2781	0,0728
Hardly	0,004	0,0073	0,2209	0,3755	0,0108	0,3044	0,284	0,1845	0,2874	0,2313	0,1807
Not at all	0,9947	0,9927	0,173	0,1495	0,9892	0,3094	0,2218	0,4267	0,2447	0,3932	0,7321
Doesn't know/won't say	0,0013	0	0,018	0,0168	0	0,0038	0,0147	0,0125	0	0,0002	0,0072
Mean	3,9973	3,9927	2,4127	2,6043	3,9892	2,8275	2,6056	2,9374	2,6689	2,9209	3,6594
Health hinderance PT											
Very	0	0	0,1931	0,1006	0	0,0612	0,1234	0,1367	0,1041	0,0998	0
Somewhat	0	0	0,2395	0,2298	0	0,1555	0,1976	0,1515	0,1959	0,1827	0,0411
Hardly	0,0015	0,0016	0,3009	0,3734	0,0056	0,3378	0,3231	0,2239	0,2939	0,2427	0,1582
Not at all	0,9974	0,9954	0,2058	0,2244	0,9924	0,4332	0,3322	0,4426	0,3934	0,449	0,7866
Doesn't know/won't say	0,0011	0,003	0,0607	0,0718	0,002	0,0123	0,0236	0,0453	0,0128	0,0258	0,0141
Mean	3,9996	4,0015	2,7015	2,9371	3,9965	3,1799	2,935	3,1082	3,0149	3,1184	3,7737
Health hinderance bicycle											
Very	0	0	0,0948	0,0219	0	0,0317	0,0742	0,1268	0,0383	0,0683	0,0004
Somewhat	0	0	0,1021	0,0744	0	0,0841	0,0943	0,0985	0,0831	0,0672	0,0229
Hardly	0,0044	0,0006	0,2376	0,2888	0,0027	0,2142	0,2349	0,1123	0,2443	0,2132	0,0806
Not at all	0,9954	0,9958	0,4562	0,5791	0,9957	0,6379	0,5564	0,3851	0,609	0,6021	0,7569
Doesn't know/won't say	0,0002	0,0036	0,1093	0,0358	0,0016	0,0321	0,0402	0,2773	0,0253	0,0493	0,1392
Mean	3,9958	4,003	3,3831	3,5325	3,9989	3,5545	3,3941	3,5876	3,4998	3,4969	4,0115
Health hinderance walking											
Very	0	0	0,1696	0,0889	0	0,0571	0,1032	0,0972	0,0909	0,0948	0
Somewhat	0	0	0,2194	0,161	0	0,1292	0,1736	0,1389	0,163	0,0996	0,0241
Hardly	0	0,0003	0,2387	0,2759	0,001	0,2299	0,2287	0,2213	0,2036	0,1787	0,1343
Not at all	0,9926	0,9967	0,272	0,3707	0,9825	0,4717	0,3685	0,5084	0,3498	0,464	0,8238
Doesn't know/won't say	0,0073	0,0031	0,1003	0,1035	0,0165	0,1122	0,1259	0,0342	0,1928	0,1628	0,0178
Mean	4,0073	4,0028	2,914	3,2387	4,0154	3,4527	3,2402	3,2435	3,3906	3,5003	3,8353

Appendix G: ODiN integration graphs



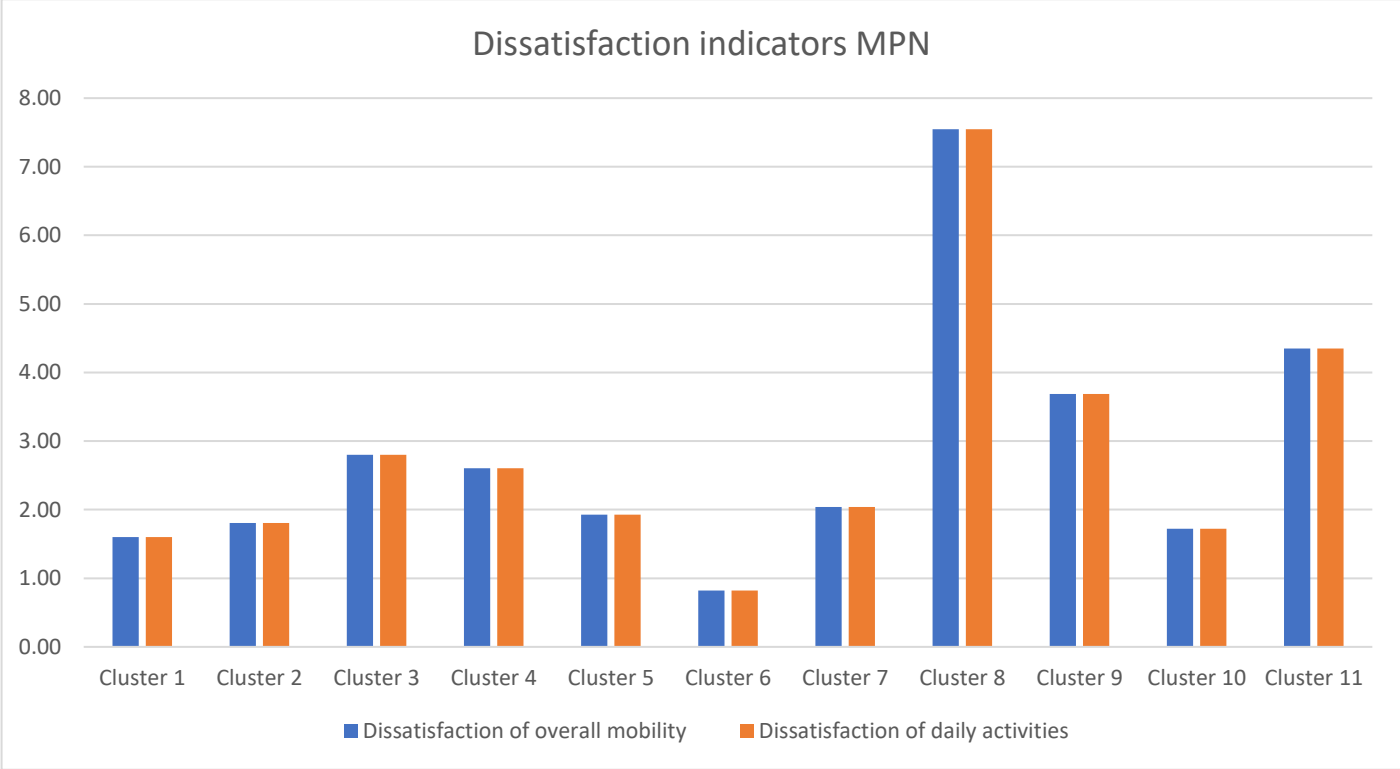


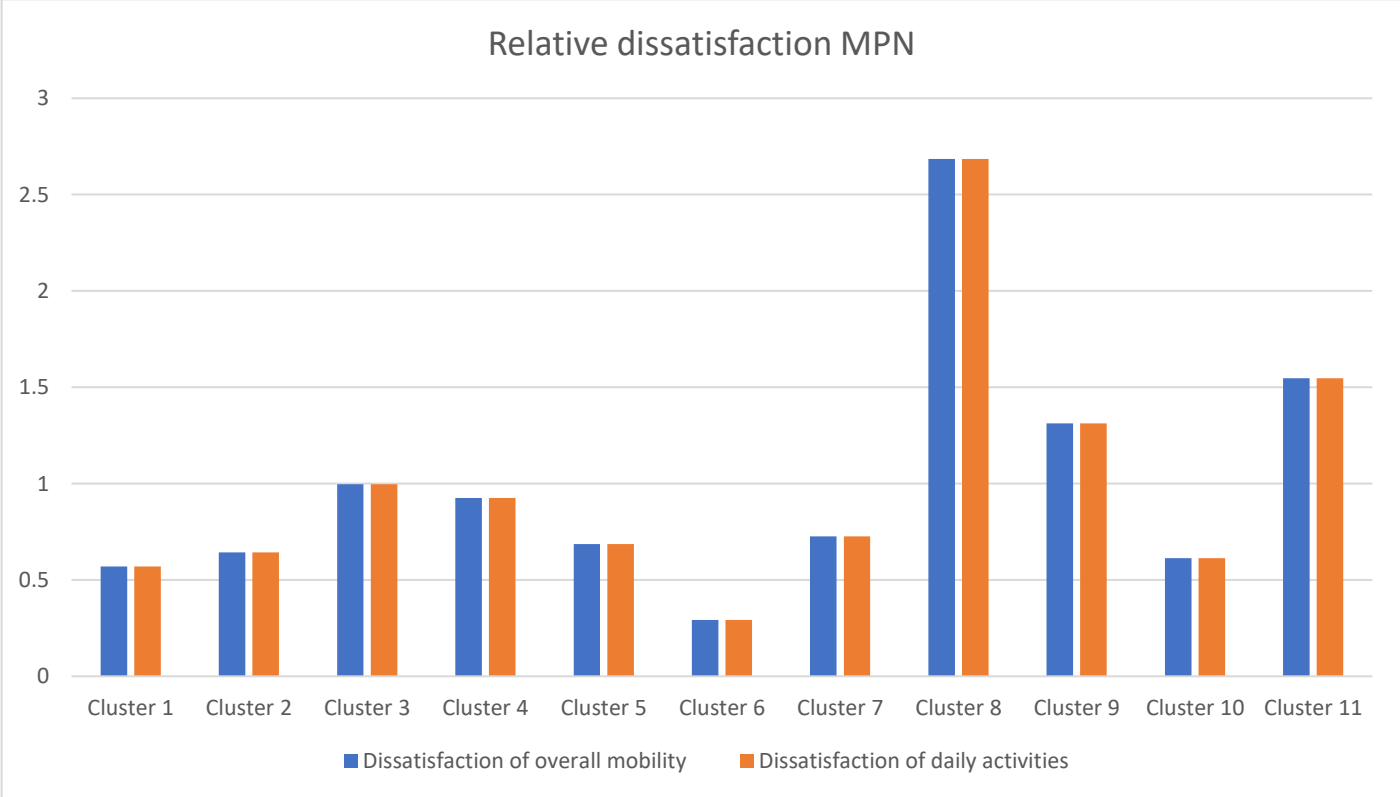
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11	GEM
Cluster size	*0,222*	*0,304*	*0,106*	*0,071*	*0,060*	*0,069*	*0,071*	*0,019*	*0,037*	*0,036*	*0,005*	
Work	1,1	1,3	3,2	2,2	0,5	1,6	1,6	3,7	2,7	1,8	2,4	2,0
School	1,5	1,7	3,6	2,7	1,0	2,0	2,4	5,0	2,9	2,4	2,3	2,5
Supermarket	1,3	1,2	7,3	4,4	0,5	3,1	4,9	4,6	4,4	4,9	2,1	3,5
Hospital	2,9	3,4	12,6	9,9	1,7	6,2	9,2	11,1	8,6	10,4	6,0	7,5
Gen. Prac.	2,5	2,5	11,9	9,2	1,4	5,5	7,7	9,3	7,7	9,8	4,9	6,6
Train Station	3,7	3,9	12,1	9,7	3,5	7,1	7,9	9,5	8,8	9,4	5,2	7,4
Busstop	3,9	3,8	12,6	9,9	3,6	6,7	8,2	8,7	9,9	10,0	4,5	7,4
Family	3,4	4,5	14,3	11,5	2,1	7,5	10,3	13,9	9,5	10,2	7,8	8,6
Sport	2,7	3,4	8,5	6,3	1,8	5,6	5,6	9,3	6,8	7,5	5,0	5,7

14.291.740,0	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**	**Cluster 7**	**Cluster 8**	**Cluster 9**	**Cluster 10**	**Cluster 11**	**TOTAL**
Cluster size	*0,222*	*0,304*	*0,106*	*0,071*	*0,060*	*0,069*	*0,071*	*0,019*	*0,037*	*0,036*	*0,005*	
Number of citizens	3.172.766,3	4.344.689,0	1.514.924,4	1.014.713,5	857.504,4	986.130,1	1.014.713,5	271.543,1	528.794,4	514.502,6	71.458,7	
Work	35.465,5	57.536,1	49.172,9	22.245,5	4.540,9	16.268,6	15.865,7	10.014,0	14.107,3	9.446,2	1.708,6	236.371,2
School	48.649,0	72.097,8	54.604,7	27.648,0	8.364,7	20.022,9	24.833,2	13.443,4	15.244,9	12.594,9	1.670,7	299.174,3
Supermarket	39.921,9	51.143,2	110.638,9	45.126,6	4.540,9	30.868,7	49.666,5	12.483,2	23.208,7	25.189,8	1.480,8	394.269,2
Hospital	92.284,5	146.681,6	191.259,6	100.104,8	14.578,5	60.903,1	93.124,6	30.179,1	45.507,3	53.528,4	4.290,6	832.442,1
Gen. Prac.	77.801,2	109.744,9	179.824,0	93.749,0	11.710,6	54.228,8	77.948,8	25.172,1	40.501,5	50.379,7	3.493,2	724.553,7
Train Station	118.837,2	169.412,0	183.254,7	98.515,9	29.635,0	70.497,5	80.018,2	25.720,8	46.644,9	48.490,5	3.721,0	874.747,6
Busstop	123.664,9	166.215,5	191.545,5	100.740,4	30.830,0	66.326,0	82.777,4	23.526,0	52.333,4	51.639,2	3.227,4	892.825,7
Family	107.881,9	194.273,3	216.703,7	116.947,9	18.163,4	73.834,6	104.851,4	37.861,0	50.285,5	52.268,9	5.543,6	978.615,2
Sport	84.671,5	149.167,8	128.078,2	63.876,4	15.056,5	55.063,1	57.254,4	25.377,9	35.723,2	38.414,5	3.607,1	656.290,5

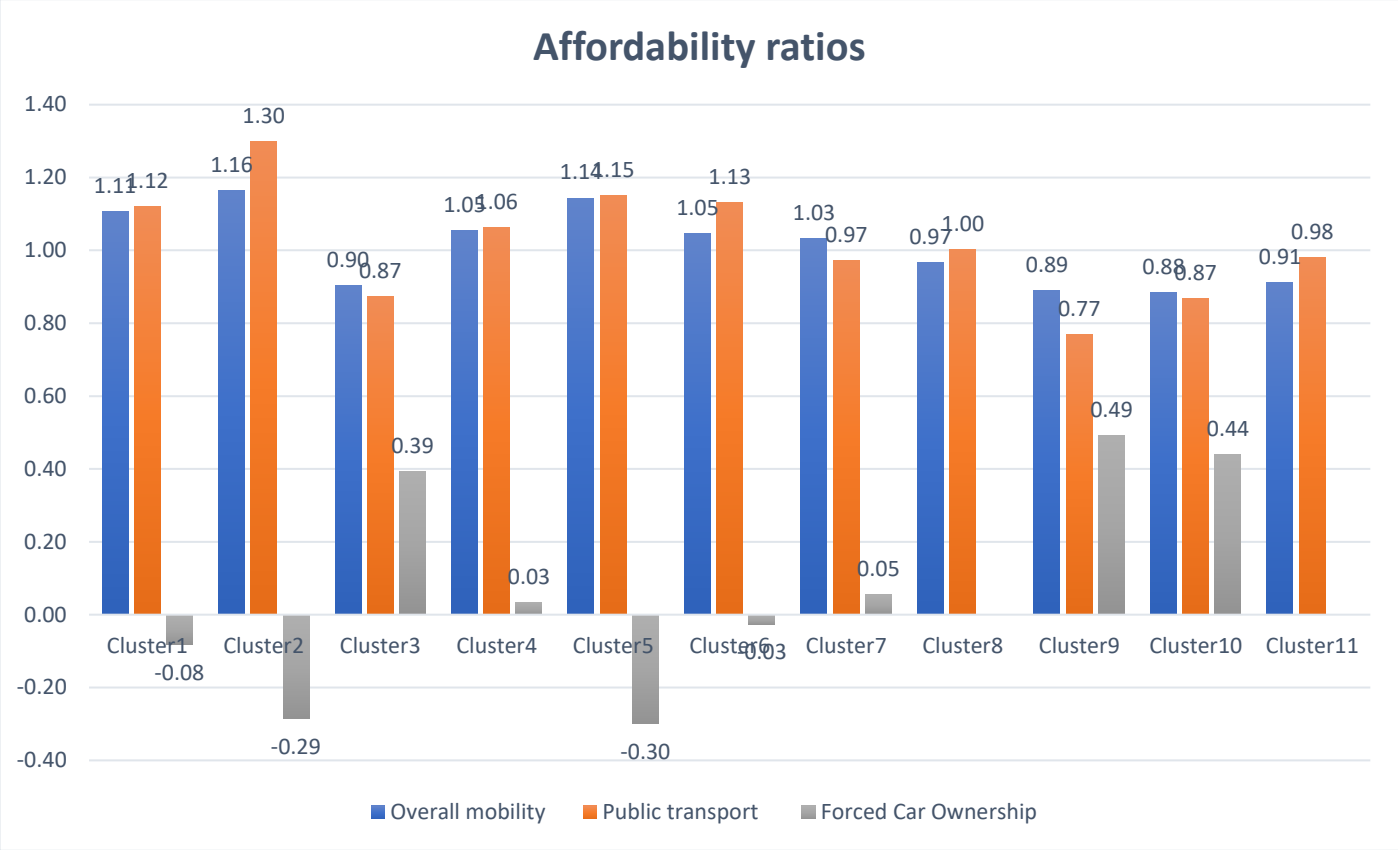
	TOTAL NL
Work	1,65%
School	2,09%
Supermarket	2,76%
Hospital	5,82%
Gen. Prac.	5,07%
Train Station	6,12%
Bus stop	6,25%
Family	6,85%
Sport	4,59%

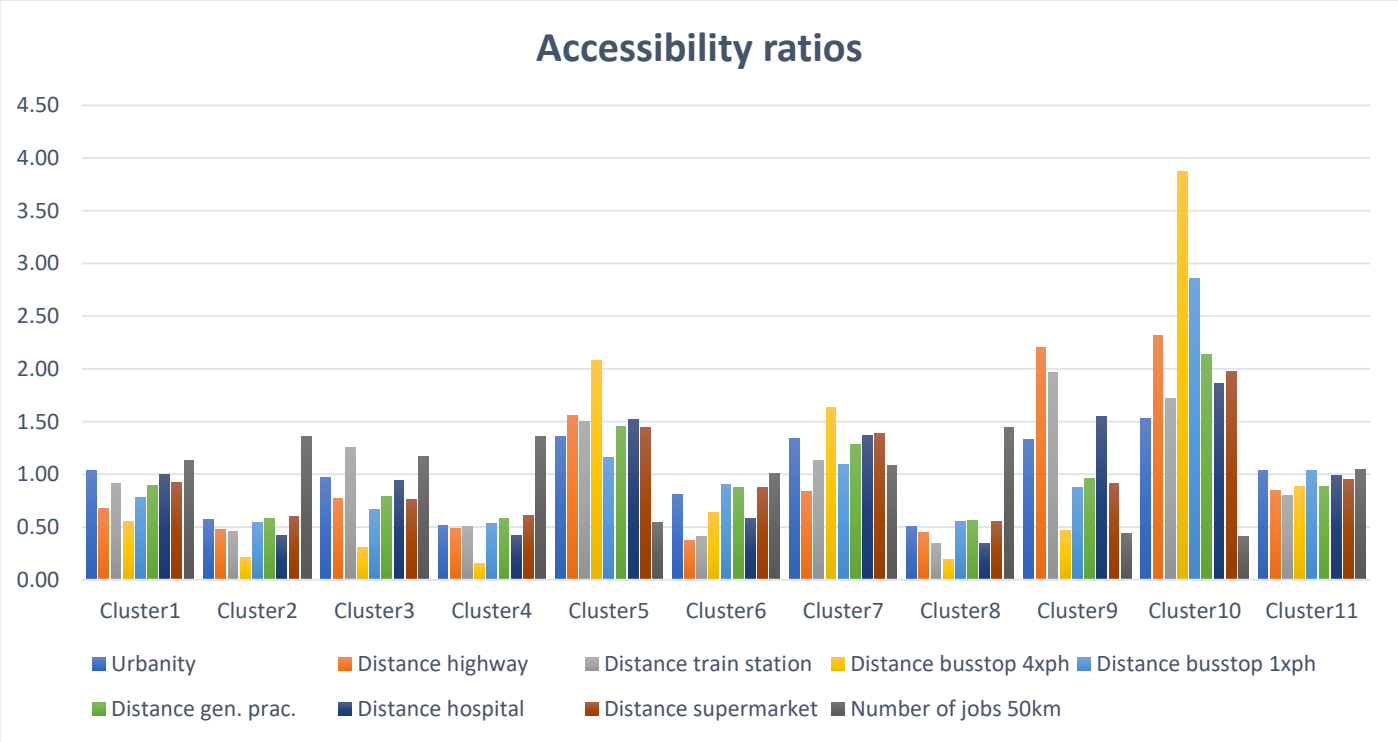
Appendix H: Satisfaction factors integration graphs





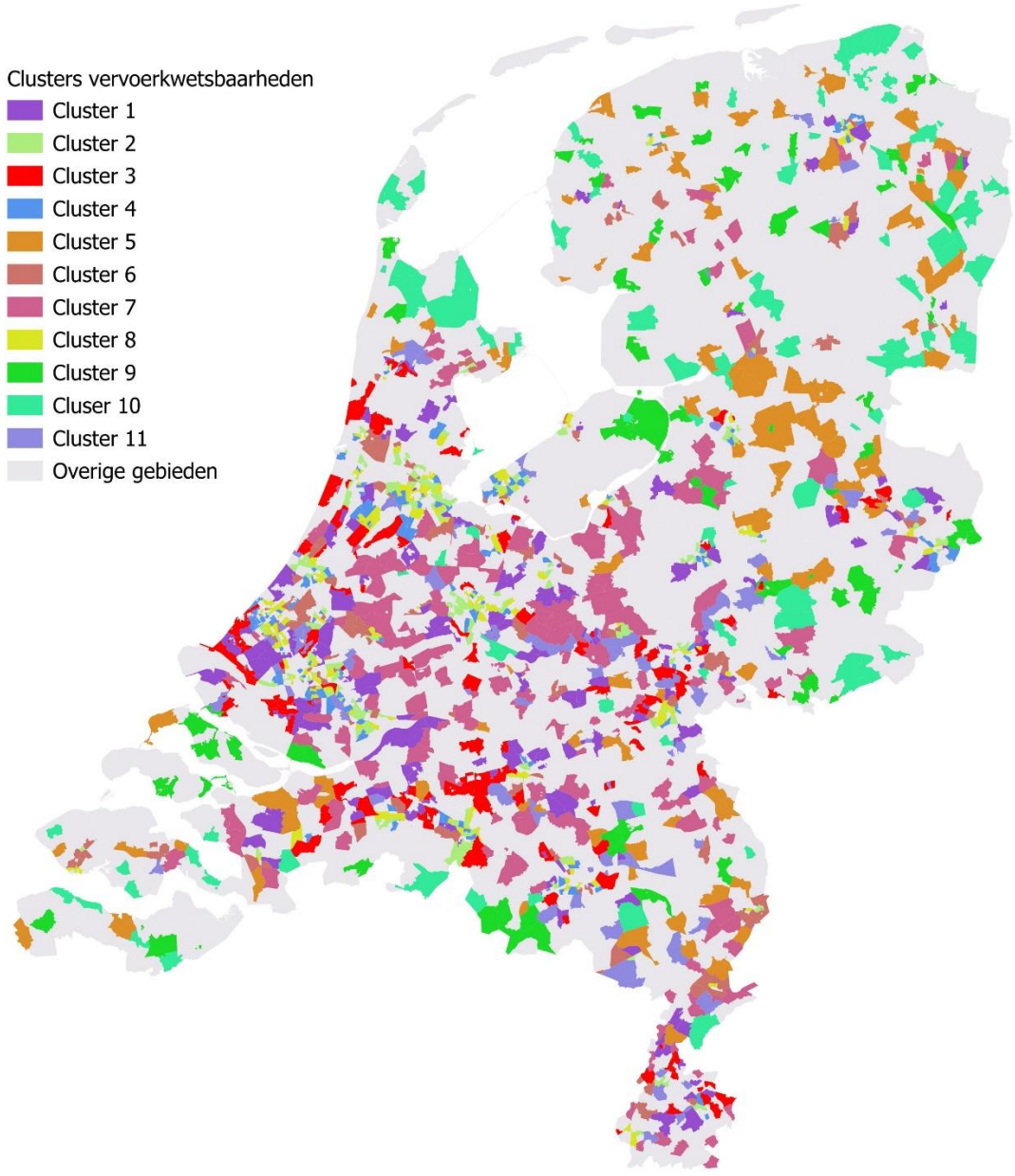
Appendix I: Relative values transport poverty aspects





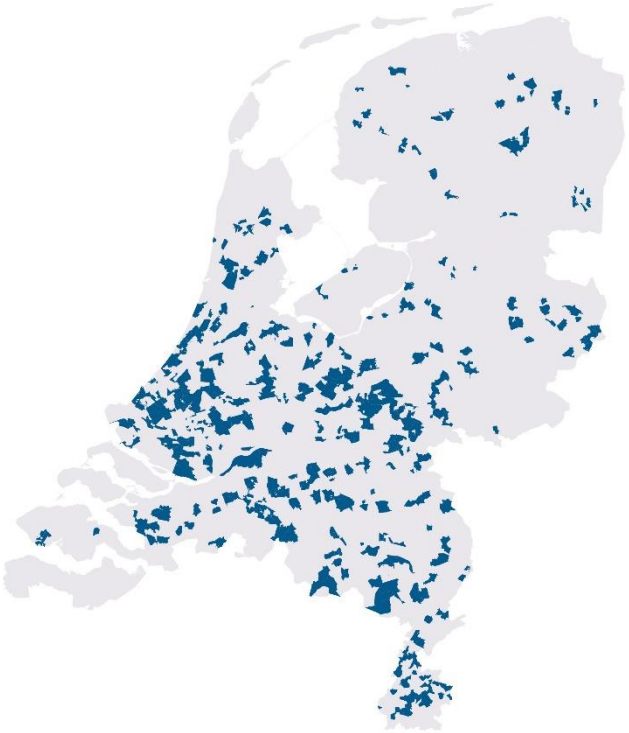

Mobility ratios
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Cluster1
Cluster2
Cluster3
Cluster4
Cluster5
Cluster6
Cluster7
Cluster8
Cluster9
Cluster10
Cluster11
Number of km as car driver
Car ownership
Bicycle ownership
Car availability
Car use
Train use
Bustrammetro use
Bicycle use
Ebike use
Walking use

Appendix J: Maps of the Netherlands

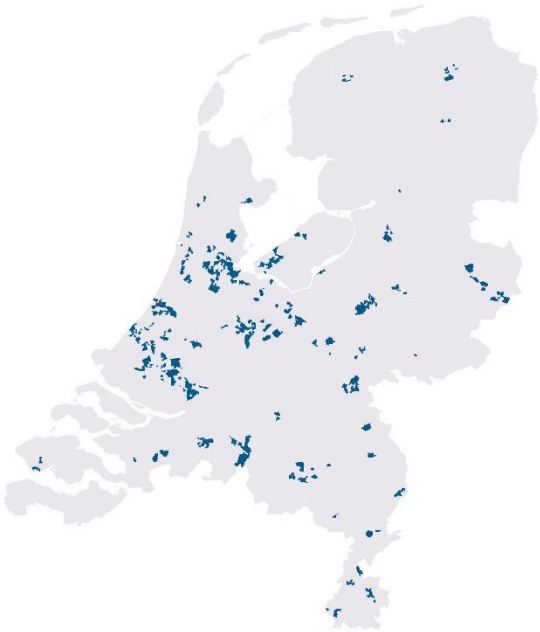


Overheersende cluster per gebied ODiN:

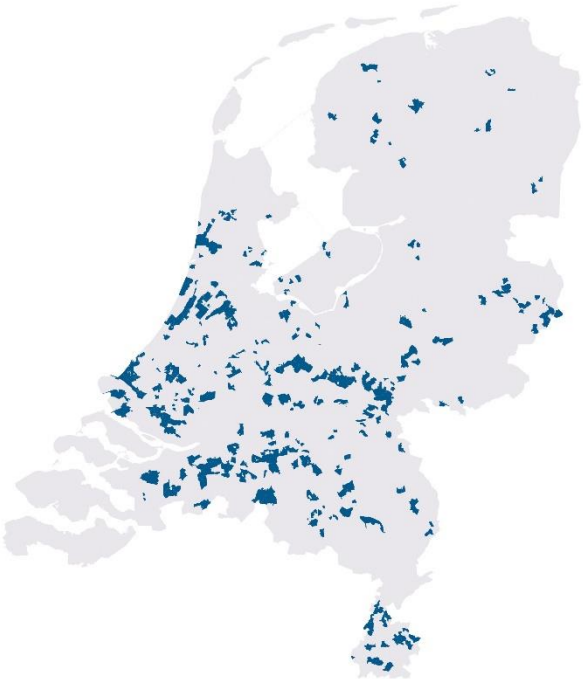
Cluster 1



Cluster 2

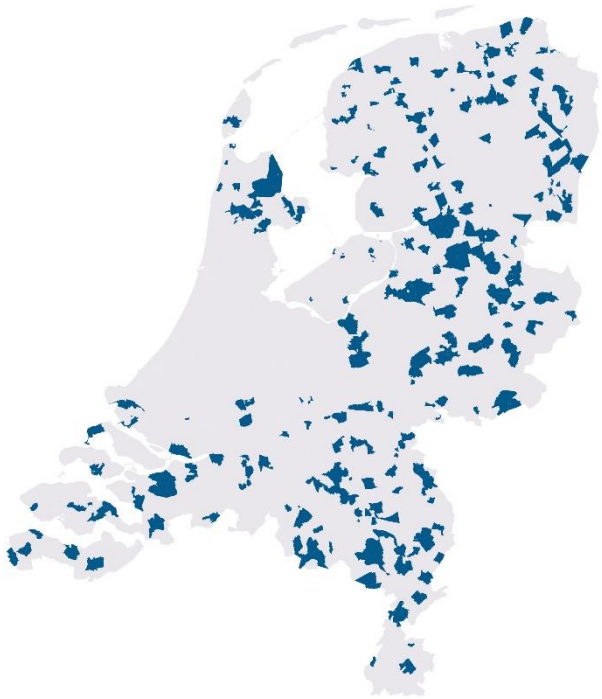


Cluster 3

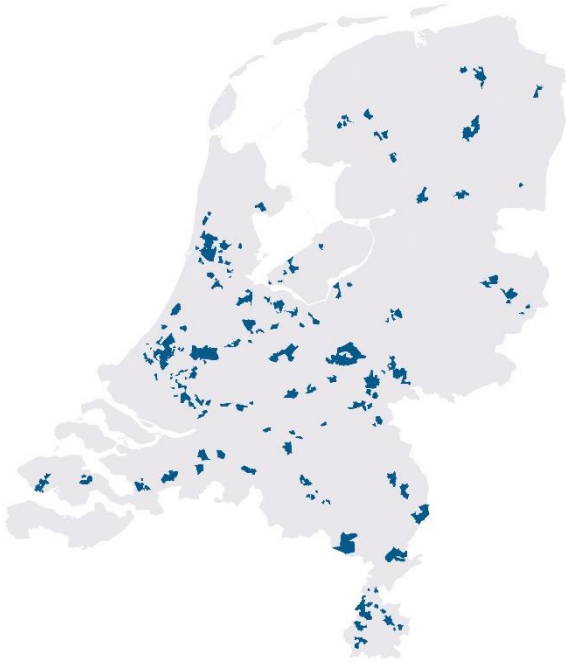


Cluster 4

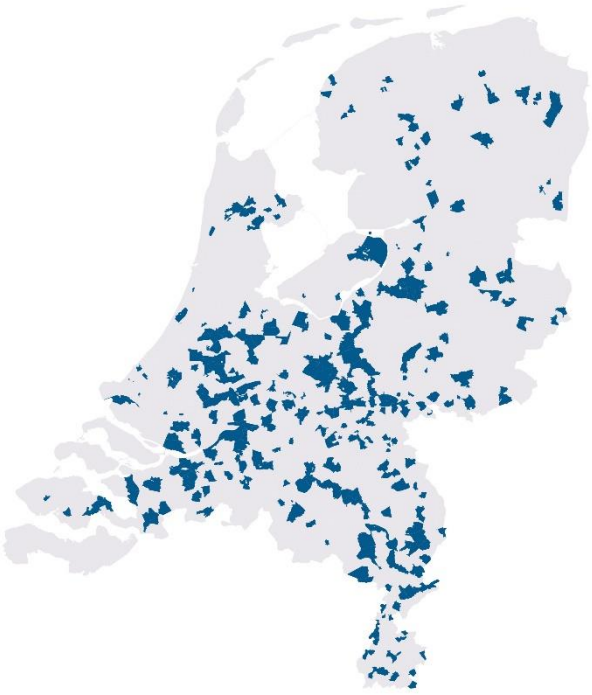
Cluster 5



Cluster 6

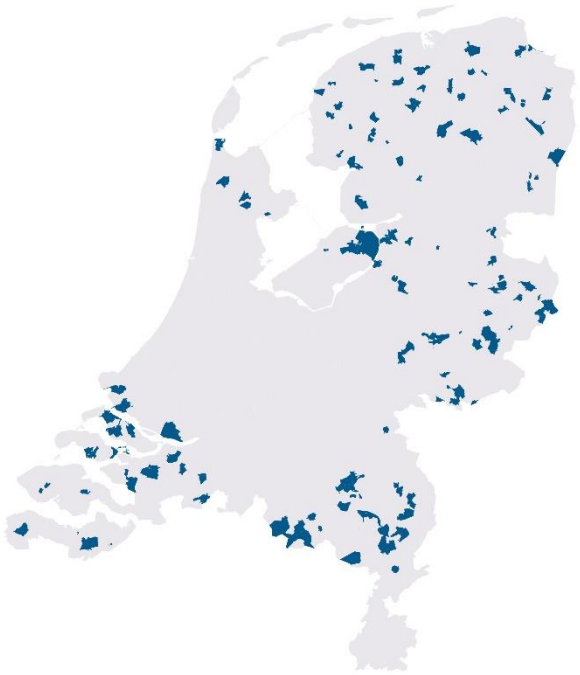


Cluster 7



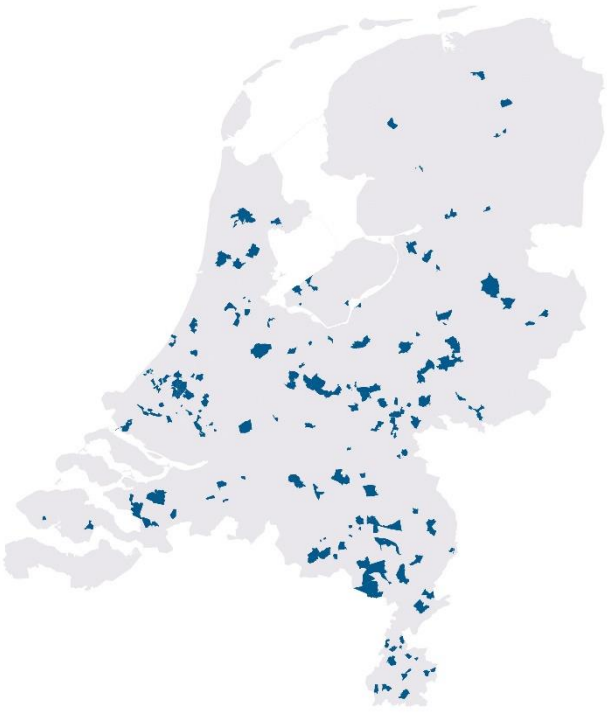
Cluster 8

Cluster 9

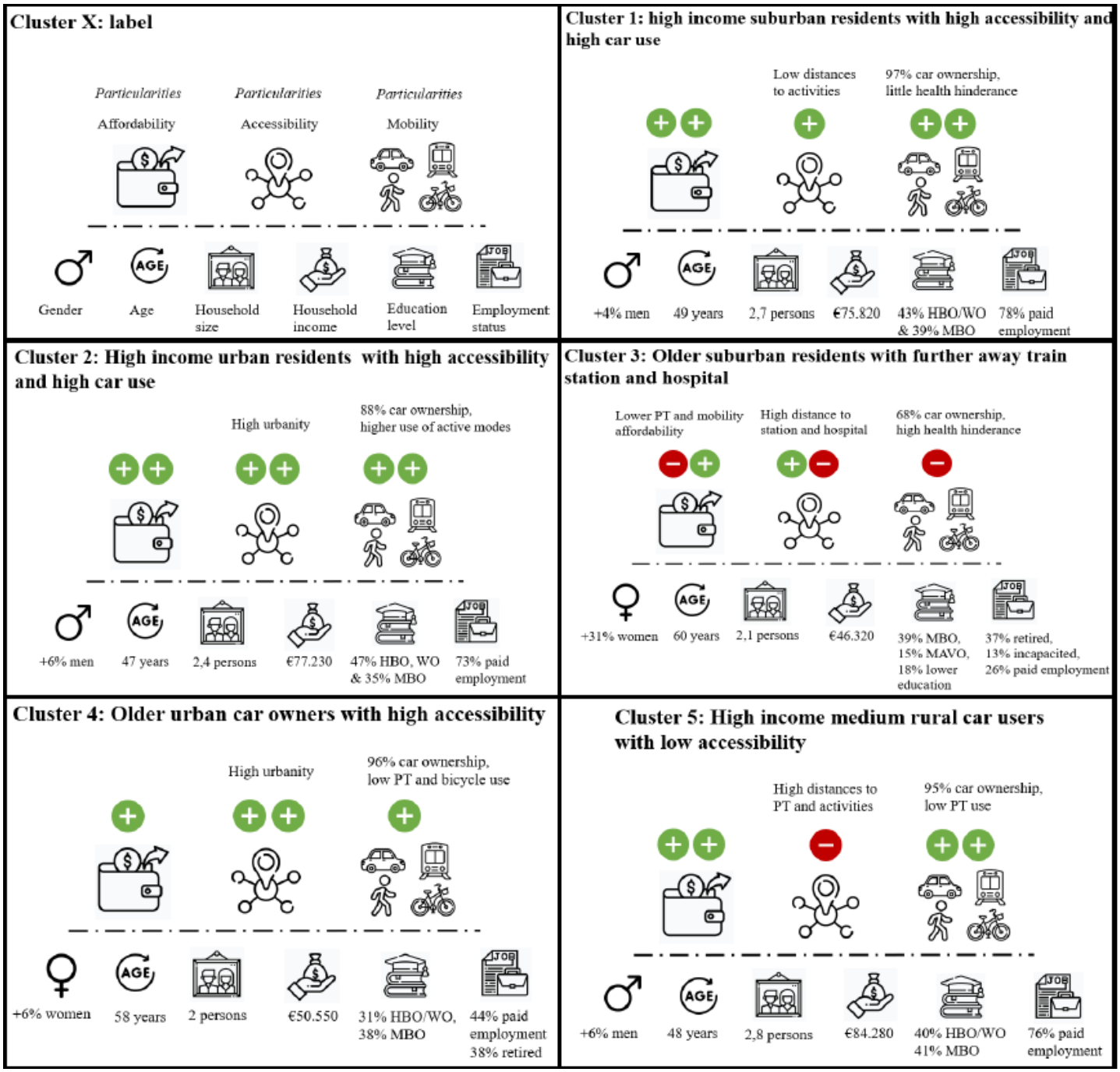


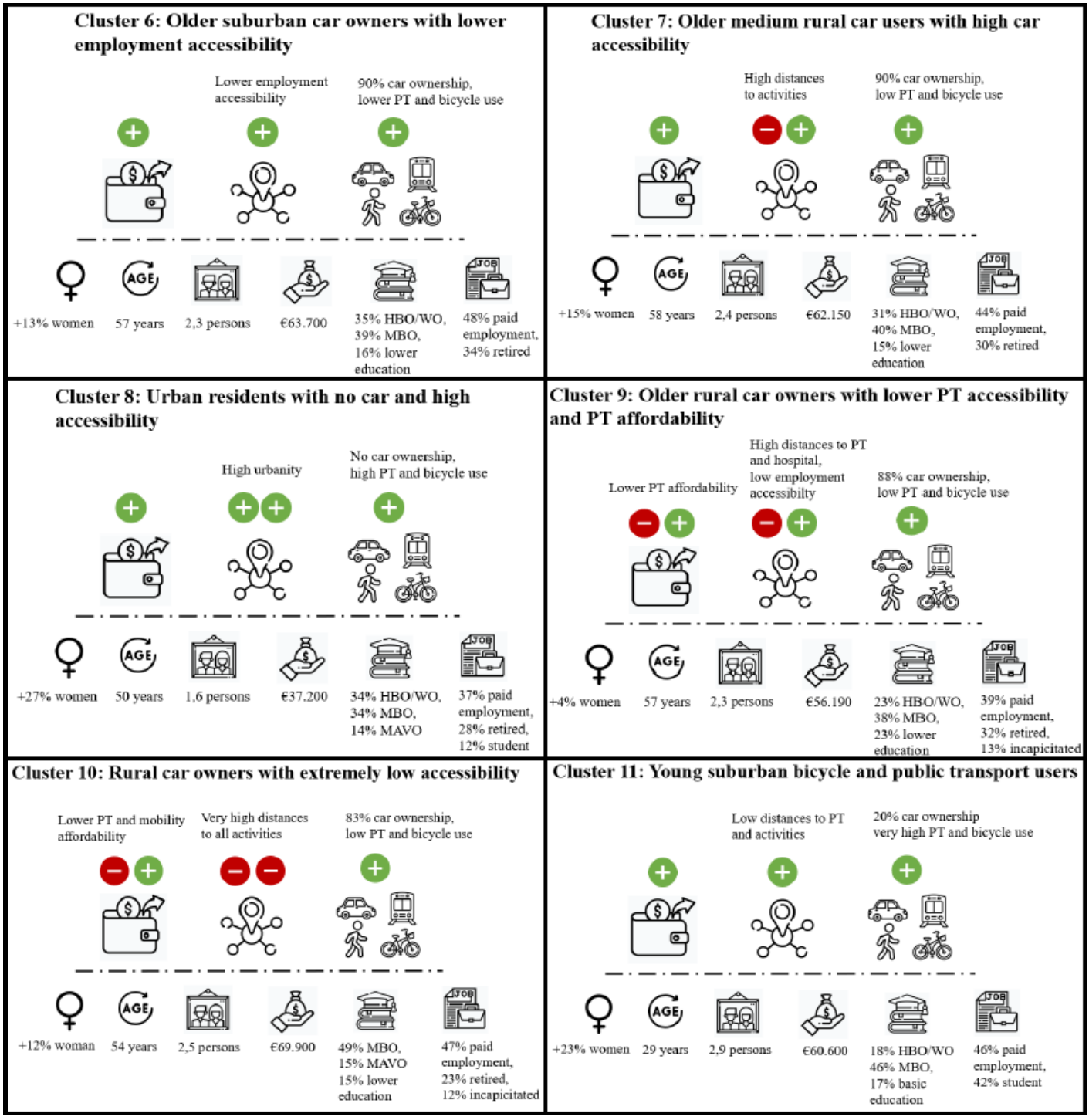
Cluster 10

Cluster 11



Appendix K: Cluster visualization




Cluster 6: Older suburban car owners with lower employment accessibility
Lower employment accessibility
90% car ownership, lower PT and bicycle use
+13% women
57 years
2,3 persons
€63.700
35% HBO/WO, 39% MBO, 16% lower education
48% paid employment, 34% retired
Cluster 7: Older medium rural car users with high car accessibility
High distances to activities
90% car ownership, low PT and bicycle use
+15% women
58 years
2,4 persons
€62.150
31% HBO/WO, 40% MBO, 15% lower education
44% paid employment, 30% retired
Cluster 8: Urban residents with no car and high accessibility
High urbanity
No car ownership, high PT and bicycle use
+27% women
50 years
1,6 persons
€37.200
34% HBO/WO, 34% MBO, 14% MAVO
37% paid employment, 28% retired, 12% student
Cluster 9: Older rural car owners with lower PT accessibility and PT affordability
Lower PT affordability
High distances to PT and hospital, low employment accessibilty
88% car ownership, low PT and bicycle use
+4% women
57 years
2,3 persons
€56.190
23% HBO/WO, 38% MBO, 23% lower education
39% paid employment, 32% retired, 13% incapicitated
Cluster 10: Rural car owners with extremely low accessibility
Lower PT and mobility affordability
Very high distances to all activities
83% car ownership, low PT and bicycle use
+12% woman
54 years
2,5 persons
€69.900
49% MBO, 15% MAVO 15% lower education
47% paid employment, 23% retired, 12% incapicitated
Cluster 11: Young suburban bicycle and public transport users
Low distances to PT and activities
20% car ownership very high PT and bicycle use
+23% women
29 years
2,9 persons
€60.600
18% HBO/WO 46% MBO, 17% basic education
46% paid employment, 42% student