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Master's Thesis – Master Innovation Sciences

Can carsharing reduce transport poverty?

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Abstract

Introduction

Business-to-consumer carsharing is a promising innovation for supporting social cohesion by improving the mobility of people experiencing transport poverty. This potential is however neglected, as carsharing vehicles are under-proportionally supplied to transport-poor neighbourhoods. This paper aims to find reasons for this and analyses the potential for introducing carsharing in transport-poor neighbourhoods, covering the perspectives of multiple stakeholders.

Theory

Roger's barriers to adoption are applied to understand what stops individuals in transport-poor neighbourhoods from adopting carsharing. Additionally, the mobility practices of households in these neighbourhoods are observed through the lens of social practice theory, which sees practices as reoccurring actions that emerge at the interplay of systems of provision and lifestyles.

Methods

Regression analysis is applied to a sample of Dutch municipalities, evaluating the relationship between the supply of shared cars and socio-economic and geographic factors linked to transport poverty. Subsequently, interviews are conducted with representatives of providers, municipalities, and social housing associations to identify mobility practices and needs, barriers, and promising strategies to increase carsharing adoption. Lastly, a user survey is evaluated to analyse the mobility practices of transport-poor households that already use carsharing.

Results

The regression analysis confirms the negative correlation between carsharing supply and factors linked to transport poverty. It also shows that some municipalities perform better than others and that there are outlier neighbourhoods, where carsharing is performing over-proportionally well. The interviews show that while mobility practices are often conducive to carsharing with multiple intervention framings applicable, there are still barriers in place, such as a lack of financial literacy, status issues, and unawareness, leading to reduced adoption and profitability concerns for providers. Strategies to deal with these barriers are diverse, including policy approaches, cooperation, and marketing efforts. The survey results show that where available carsharing can be a beneficial mobility alternative for some transport-poor households when integrated into a transport mix.

Conclusion

This research helps to understand the unused potential for social equity impact when it comes to introducing carsharing in transport-poor neighbourhoods. While emphasizing that carsharing is not a solution for all mobility needs and all individuals affected by transport poverty, it is shown that it can mean an improvement for many, offering financial savings to those who previously owned a car and a larger mobility radius to those who did not. More support from municipalities as well as knowledge exchange and cooperation between stakeholders are however necessary to realise this potential.

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1. Introduction

Anthropogenic greenhouse gas emissions are causing the earth to warm at an alarming rate. This can already be seen in the retreating of glaciers and the rising of sea levels (IPCC, 2021), but scientists agree that this is only the beginning unless humanity adopts more sustainable approaches to consumption. Amounting to almost one quarter of Europe's greenhouse gas emissions (European Commission, 2021b), the transport sector is playing a key role in halting climate change. This issue is addressed in the transition towards the electrification of our transport system. But in addition to the emissions caused through the combustion of fossil fuels, there is another factor making a transport system which is relying on personal vehicles unsustainable. The resources and raw materials needed to produce vehicles are plentiful with the pace of decarbonization of material production expected to be slow (Pauliuk et al., 2021). The issue is further exacerbated by growing population numbers and increasing motorization rates in developing countries (Trouve et al., 2018). In many Western countries, it is even common for a family to own two vehicles, while on average cars are unused 95% of the time (Bates & Liebling, 2012). This is an inefficient use of our limited resources and leads to unnecessarily high emissions caused in the production processes. As a result, the decoupling of the service of mobility from the number of vehicles needed becomes a central task (Creutzig et al, 2018).

Carsharing is one suitable strategy to achieve this decoupling and reduce car ownership. It is a membership-based service that allows individuals to rent vehicles available in their proximity for short periods of time. It stands in contrast with the dominant model of private car ownership and the perception of the car as a status symbol (Meelen, 2019) and has the potential to reduce the number of cars needed to support the demand for mobility of a population with estimates stating that one carsharing vehicle can substitute for up to 20 personal vehicles (Jochem et al., 2020). A distinction can be made between two types of carsharing: The first type, peer-to-peer carsharing enables private car owners to rent out their own vehicles to other users when they do not need them themselves. This is facilitated by a carsharing organisation that provides the platform and facilitates the matching process and additional services. In the second type, business-to-consumer (B2C) carsharing, the cars are instead supplied by a business provider who owns the entire fleet of vehicles offered on the platform and stations them dispersedly across neighbourhoods (Münzel, 2020a). This paper is focused on the B2C carsharing model, which will in the following be addressed simply as 'carsharing' - a decision that is explained in further detail later on. Another further distinction in B2C carsharing business models can be made between a roundtrip and a one-way system. In the roundtrip system shared cars have to be returned to the same parking spot that they were taken from, while in the one-way system they can be returned to a different location. In this system, station-based shared cars have set parking spaces or parking areas that they need to be returned to by the user at the end of the rental period while free-floating carsharing services provide the user with more freedom, as cars can be left anywhere inside the designated business area of the provider (Münzel, 2020).

While the concept is not new, carsharing has grown in importance over the last years – with the global revenue and user number steadily increasing globally (Statista, 2022). In the Netherlands, 730,000 people used shared cars in 2020, up by 42% compared to the previous year (CROW, 2022). This gain in momentum fits in with a phenomenon referred to by Grassmuck (2012) as the "sharing turn" in the economy, describing the trend that products are increasingly shared rather than privately owned. This relates to the development that consumers are more and more valuing access-based consumption over ownership (Münzel, 2020). It can be traced back to the 2008 financial crisis, which led many people to rethink their consumption patterns and the value of ownership (Gansky, 2010) and hence created favourable conditions for the growth of a whole range of business models

based on the sharing of resources, from coworking spaces to tool sharing and ridesharing – and also carsharing. Benefits attributed to sharing-based business models are a positive environmental and social impact (Botsman and Rogers, 2011) which are induced through the saving of scarce resources and the stimulation of social cohesion (Agyeman, 2013).

With wide-ranging benefits, the motivations for consumers to participate can therefore also be various: they can range from economic to social and environmental drivers (Böcker & Meelen, 2017). They also vary between the different types of products that can be shared. Research therefore needs to be specifically targeted at a certain product to deliver valuable insights. For carsharing, it has been shown that it can alleviate environmental concerns related to car ownership (Nijland & van Meerkerk, 2017) and also allow for considerable financial savings compared to private car ownership, depending on the distance driven. More specifically, a study in Germany found that from a financial perspective carsharing makes sense for those users who drive less than 10,000 km per year, as with higher vehicle kilometres the driving of a driver-owned car becomes the cheaper option (Circular Impacts, 2018). The details on this calculation can be found in Appendix A. Similarly, according to a tool conceived by the Belgian carsharing organisation Autodelen.net which considers different inputs such as car type, trip purpose, frequency, distance, and duration, carsharing is almost always the cheaper alternative to private car ownership for anyone driving up to 15,000 km per year and depending on the input factors this number can sometimes even go up as far as 20,000 km per year. As the average Belgian drives about 15,000 km a year, carsharing can therefore provide a more economical alternative for many households (Autodelen.net, 2020). Böcker and Meelen (2017) show that the motivations for using carsharing vary between users belonging to various social groups: it was found that women and highly educated groups are more environmentally motivated, while lower-age groups as well as lower-income groups are more economically motivated. Because socioeconomic characteristics vary geographically between neighbourhoods, this is likely to also lead to differences in motivation between the users in different neighbourhoods.

But apart from motivations, other factors can play a crucial role in deciding whether potential users consider carsharing to be a relevant option for them, such as consumer practices (Hesselgren et al., 2020). These can be understood to be the ways in which potential users are currently used to fulfilling their mobility needs and might include commuting in a private car, using the family car for running errands, or relying on public transport. Similar to motivations, consumer practices are also expected to vary geographically in response to the socio-economic characteristics of neighbourhoods but also geographical factors such as the availability of public transport and proximity to establishments such as schools and supermarkets (Everts et al., 2011). For it to be adopted by residents, it is important for carsharing to become integrated into the mobility practices of people in a certain locality and offer some sort of improvement. This improvement can be especially potent in areas where mobility is currently scarce.

Costs for car operation and maintenance have been increasing, highlighting carsharing as a way to reduce spending on a private vehicle while maintaining the car as a mobility option (Martin et al., 2010; Cervero et al., 2007; TCRP, 2005). This makes it interesting as a more affordable mobility alternative for households facing transport poverty. The term transport-poor describes households that spend at least 10% of their expenditures on how their members move from one place to another, a situation which mostly occurs in neighbourhoods that host a relatively low-income population, offer little public transport connectivity, or are situated in remote locations (Gallerand, 2021). The low accessibility of transport in many neighbourhoods exacerbates the residents' financial burdens (Kyeongsu, 2015). It leads to a lower accessibility of resources and opportunities, such as jobs, shopping, and social activities (Litman, 1999). And in turn, this limited access worsens

the poverty and social disadvantages of residents (Lucas, 2012). The interaction of these mechanisms can be depicted in Figure 1. It shows how the elements of social disadvantage and transport disadvantage come together to cause transport poverty, how transport poverty leads to the inaccessibility of resources and opportunities and how this, in turn, gives way to the social exclusion of individuals experiencing transport poverty. By making vehicles available to the residents of such localities at an affordable price, carsharing can help to reduce this social exclusion achieving a real social impact.

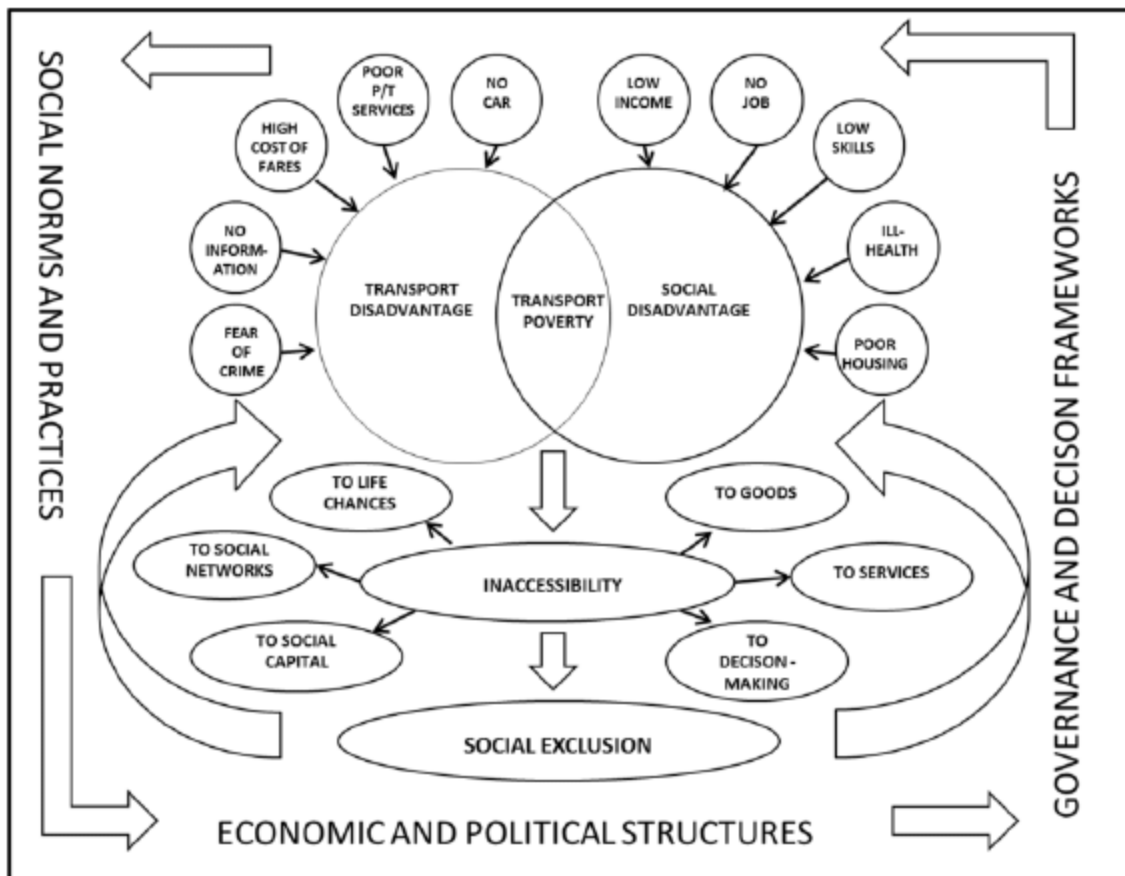


Figure 1: The relationship between transport disadvantage, social disadvantage, and social exclusion (Lucas, 2012, p. 107)

Yet currently the reality of geographical distribution of B2C carsharing does often not allow for this social impact. A study on carsharing usage patterns in New York City revealed that “transportation-excluded urban peripheries [were] little served by current commercial carsharing programs” (Kyeongsu, 2015, p. 250). This can be the case because the longer distances to facilities like supermarkets and schools encountered in transport-poor neighbourhoods, can increase the dependence on car ownership, which in turn could decrease the demand for carsharing. Equally, the lower public transport accessibility within a transport-poor neighbourhood can also lead to a higher dependency on private vehicles, again potentially decreasing carsharing demand. Lastly, in the Netherlands it has been found that carsharing which is offered through commercial providers is largely limited to serving user groups with higher income in order to maintain profitability (Petzer et al., 2021). This builds on the hypothesis that the higher the average income within a neighbourhood, the higher the demand for shared cars. The combination of the previously cited factors leads to a lower attractiveness of transport poor neighbourhoods for B2C carsharing providers, as the profitability of providing the service is uncertain. Profitability, however, is key for achieving the

potential social impact, as the providers will only offer the service if they can expect a financial gain from it. As demand is indispensable for profitability, research needs to be done to understand the demand for carsharing that is currently present in transport-poor neighbourhoods in the Netherlands and find out more about how the carsharing business model and potential users' mobility practices, could be adapted to increase demand.

In fact, a study on carsharing usage data in New York City found that the demand for carsharing in low-income neighbourhoods was no different from the typical carsharing locations if the offer was affordable (Kyeongsu, 2015). More even, because of the different socio-economic characteristics, motivations and mobility practices in such neighbourhoods, a different dynamic might present itself that is actually favourable for the profitability of B2C carsharing services. It could for example be hypothesised that low-income households that cannot afford private car ownership, would have a higher willingness to adapt their mobility habits. Petzer et al. (2021) found that non-profit stakeholders from both the mobility and the housing sectors in the Netherlands perceived the current offer of commercial carsharing to still leave a large unmet need for carsharing among lower-income households. However, the non-profit housing sector has so far engaged only little in such shared mobility schemes. One reason study respondents provided for their hesitancy in securing access to carsharing for their tenants was their already complex sustainability agenda (Petzer et al., 2021). Social housing associations should however view mobility as an essential need of their tenants which is best met by shared mobility (Petzer et al., 2021).

The growing user base of carsharing providers suggests future growth in the geographic area covered by the service, as a saturation of the neighbourhoods currently served will lead companies to expand in order to preserve or grow their revenues and profits (Kyeongsu, 2015). Therefore, it is important to make a scientifically founded case for the potential of these transport-poor neighbourhoods in the Dutch context, which both residents and providers will be able to benefit from. It should however be noted that this research only considers those transport-poor neighbourhoods that are located in the centre or urban periphery of cities. This delimitation has been chosen because localities in a rural context generally provide a challenging market for carsharing providers due to factors such as the lower population density making economic sustainability unlikely (Seemann & Knöchel, 2017). Accordingly, previous studies mention the effect of the population density as an explanatory factor for carsharing diffusion, since vehicles stationed in a more densely populated area are within reach for more potential users, increasing profitability (Millard-Ball et al., 2005).

The decision to focus this research around B2C carsharing was taken for multiple reasons: First, this paper specifically targets transport-poor neighbourhoods as expansion markets for current carsharing providers. This implies that such a manipulation of the supply of shared cars in these geographic areas must be possible. As with peer-to-peer carsharing the users themselves supply the car this is much harder to manipulate. Further, as peer-to-peer carsharing still relies on private car ownership of those users that rent out their cars to others, this business model presupposes some share of private car ownership in the community, which might lead to a bottleneck in transport-poor neighbourhoods. Additionally, as a focus of this paper is to identify strategies for businesses in the carsharing sector, B2C carsharing becomes more interesting, as the potential revenue for providers is larger. Lastly, B2C carsharing has also been shown to achieve a larger positive impact on environmental sustainability (Nijland and van Meerkerk, 2017), as it more often leads users to give up on their own cars and reduce total kilometres driven.

Research so far is often focused on understanding the benefits of carsharing (Botsman and Rogers, 2011), which consumers adopt carsharing and for what reasons (Böcker and Meelen, 2017;

Burkhardt and Millard-Ball, 2006; Lindloff et al., 2014), the logistic optimization of carsharing systems (Vosooghi et al., 2014), measures to support the carsharing niche (Münzel, 2020), as well as discerning the different carsharing business models (Clark et al., 2014, Cohen and Kietzmann, 2014, Münzel et al., 2018). In a recent study, Münzel (2020) adopted a new focus on the spatial factors which lead to differences in carsharing supply between cities and countries. This has been a development from earlier studies that were mostly limited to a focus on specific cities, without aiming for intercity comparison beyond two cities. This research again offers new insights as the neighbourhood level, which is addressed here, has previously only been studied within the same city (Kyeongsu, 2015). A comparison of neighbourhood-level units between multiple Dutch cities is however still missing and is an important progression in terms of sample size and reproduction of results. Further, this research can help to bring more clarity about the effect a strong public transport system can have on carsharing demand. Existing research offers conflicting results: on the one hand, good public transport connectivity can make it easier to live without a car and adopt a multi-modal lifestyle, but a weaker transport system on the other hand can make carsharing more useful. Lastly, based on the findings of earlier studies the country context is an important predictor for carsharing success: Shaheen and Cohen (2013) found that differences in infrastructure and institutions such as regulations, tax regimes and support policies create decisive differences between nations. This is also supported by Münzel (2020) in her study which considers carsharing across multiple countries. As the focus of this research is put on the neighbourhood analysis, the scope is limited to neighbourhoods in Dutch municipalities. The study will however analyse whether a similar effect can be observed at the municipality level, where differences in the local regulations or policy support might lead to better or worse conditions for carsharing.

The research addresses the general question: Does B2C carsharing bear the potential to become a viable and beneficial mobility solution for transport-poor neighbourhoods and what strategies can be employed to promote this? To operationalize this research question, it is divided into several sub-questions which correspond to the various parts of this research. In the first part, the assumption is tested that there currently is a situation where transport-poor neighbourhoods are supplied with disproportionately few carsharing vehicles. This is done quantitatively based on the analysis of aggregated data on the neighbourhood level, focusing on the number of shared cars supplied and several geographic and socio-economic factors relating to transport poverty. Defining transport poverty at the neighbourhood level and based on aggregated data means that significant differences can still exist among households within a neighbourhood that is identified to be transport-poor. There could for example still be households with a high-income within that neighbourhood. However, statistically, a large share of the households within these neighbourhoods can be expected to experience transport-poverty. Subsequent to the regression analysis, qualitative analysis is conducted to answer the second and third sub-questions. Interviews are held with representatives of providers, municipalities, and social housing associations, to unravel more about the individual circumstances in place in a several neighbourhoods found to have a relatively high or very low supply of shared cars. These interviews also serve to find out more about the potential for B2C carsharing in transport-poor neighbourhoods by investigating households' mobility practices, needs, barriers to adoption, and possible stakeholder strategies to increase carsharing uptake. In a last quantitative step, results of a user survey with carsharing users in transport-poor neighbourhoods are evaluated to understand whether the insights gained from the neighbourhood analysis are congruent with the experience of individual low-income households, focusing especially on their motivations for adopting carsharing as well as their mobility practices.

The relevance of answering the research question is threefold: First, analysing a market segment with regards to its potential for a geographical expansion of carsharing services helps providers by

delivering them with a basis for strategizing and designing their offer. This allows them to grow the reach of their business leading to economic benefits. Second, this development can also create a positive environmental impact, as carsharing can reduce the resource inefficiencies caused by private car ownership. And third, a social impact is made by finding ways to use the growth of the carsharing business to alleviate the problems that exist in transport-poor communities. By combining the aim for profitability and sustainability, the idea is that strategies with a high realisability can be conceived, as the focus is placed both on achieving social impact and creating value from a business perspective. This can lay the groundwork for cooperation between providers, municipalities and social housing associations, as well as providing a basis for creating well-aimed policy measures. The Netherlands provides good conditions for achieving interesting insights as it is already host to a relatively large number of shared vehicles. It therefore offers many data points, and the knowledge base of the population can be assumed to be relatively high, facilitating the interview process.

The paper continues with a theory section describing the theoretical background upon which this research is based including an explanation of how the theories are combined in a conceptual framework. Then the research structure is briefly explained, followed by three subsections which each adopt a separate research method to respond to different sub-questions. These three sections are each structured in methods, results, and discussion, with the first section being about regression analysis, the second about stakeholder interviews and the last about a user survey. Subsequently, the conclusion is drawn combining insights from all three subsections.

2. Theory

To develop an analytical lens on the research question, elements from both adoption theory and social practice theory will be combined and supplemented with literature on business model innovation.

Adoption theory

Adoption theory provides the theoretical basis for this research, as it deals with the individual's choices to accept or reject an innovation. Various theories on adoption are applied in the literature. What they agree on is that adoption is a process rather than a single event, as it depends on beliefs and attitudes that are formed over time (Straub, 2009). Roger's Innovation Diffusion Theory (1962) provides a broad foundation for understanding individual adoption and collective diffusion of innovations. It describes the adoption decision process to be consisting of five stages starting with the awareness of an innovation. This awareness is influenced by personal characteristics, socioeconomic characteristics, and access to change agents, such as the mass media. In stage two, persuasion, the individual learns about the innovation's salient characteristics and makes a personal judgement on whether they see the innovation favourably or not. In stage three a decision is made whether to adopt or not adopt the innovation. Stage four, implementation is the enactment of the previous adoption decision and in stage five, the confirmation stage the individual reflects on the decision and re-evaluates their adoption (Rogers, 2003).

Rogers further identifies that the speed of adoption is influenced by five main attributes of an innovation: the relative advantage, compatibility, complexity, trialability and observability. The relative advantage describes to what extent the innovation is perceived to be better than what it replaces. The relative advantage of lower costs is likely to be an important factor for the adoption decision of transport-poor households. As those households dispose of a low income and carsharing is often more economic than a private vehicle, this could make an important difference for them.

The higher the perceived importance of this advantage the faster will be the adoption. The compatibility talks about the consistency of the innovation with the values and experiences of the potential adopters. This could hold back adoption as carsharing goes against the traditional system of car ownership which is embedded in society through values such as seeing the car as a status symbol. Complexity is about the difficulty of understanding and using the innovation. Here, the increase in vehicles stationed across cities in the Netherlands and the growing number of users might have already led to a general understanding of carsharing among the population, however, this might not be the case in transport-poor neighbourhoods if these are found to be underserved. Another challenge here might be the need for a driver's licence to use the carsharing service. Trialability describes the extent to which the innovation can be tested before the purchase decision. This might increase the interest in carsharing among those in transport-poor neighbourhoods that have not had any personal experiences with carsharing yet and might be sceptical. And lastly, observability is the extent to which the innovation provides results that are tangible for a potential adopter. This is another factor that may be lacking in neighbourhoods that are underserved by providers as the innovation is not visible there (Rogers, 2003; Straub, 2009).

Social practice theory

Adoption literature does however not provide a perfect fit for the context analysed in this research. This is because adoption decisions regarding mobility are often more complex: rather than the individual, it is the household that owns private cars that they share internally. Therefore, also the adoption of carsharing is usually a decision made by a household rather than each individual on their own. Adoption theory however has the limitation of reasoning from the individual perspective. While it does recognize that the social system – meaning the context, culture, and environment of the individual, is one of the components of innovation diffusion, it does not provide a framework for a deeper understanding of the underlying processes (Straub, 2009). As it is missing this integration of the social environment it also fails to adequately consider the daily practices that the product or service needs to be integrated into or that need to be adapted.

By extending the understanding of adoption theory with insights taken from social practice theory - a branch of literature that studies lifestyles and their formation in interaction with an individual's surroundings, it will be possible to consider usage patterns that are closer to reality (Hesselgren et al., 2010). Giddens (1991) defines lifestyles as a set of social practices, such as travelling by car, that are embraced by the individual and that includes the storytelling that rationalises these practices. By putting an individual's responsibilities and possibilities in relation to its surrounding socio-material structures (Spaargaren, 2003) social practice theory shows that lifestyles depend on the connecting systems of provision and structures around the individual (UNEP, 2016). This is demonstrated in Figure 2 where the observable behaviour of an individual which is associated with the performance of a practice is only the visible tip of the iceberg. The much larger submerged portion of the iceberg however represents the practice as an entity and includes much more than is evident at first sight: the socially shared tastes and meanings, the knowledge, and skills of the individual and the materials and infrastructures of the system of provision which all play a crucial role for the adoption of a practice.

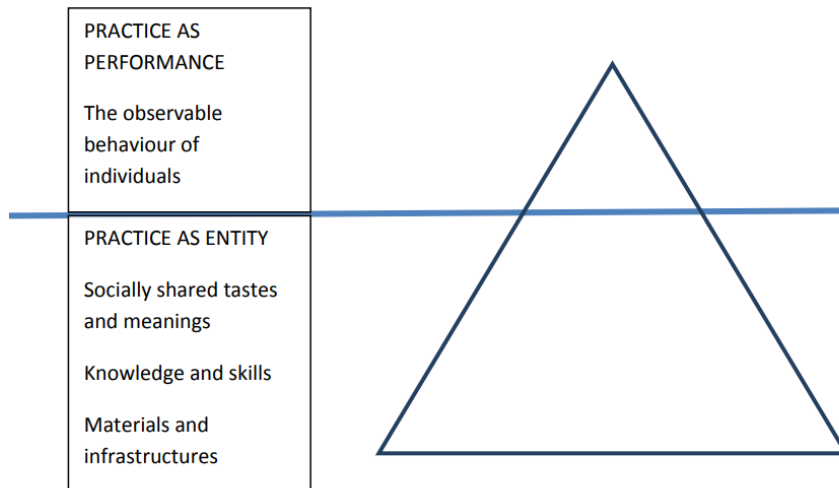
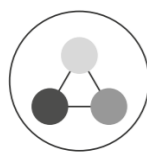


Figure 2: Observable behaviour as a small component of practices (Spurling et. al, 2013, p. 8).

This perspective coincides with the conceptualisation developed by Shove et al. (2012), shown in Figure 3 which states that each practice emerges from the combination of *three types of elements*. Elements in all three element types must exist and be linked for people to be able to perform the practice. These are the materials, such as objects, tools and infrastructures needed; competences, such as knowledge and skills and the meanings such as cultural conventions, expectations, and shared meanings (Shove et al., 2012). With regards to carsharing, materials could mean the shared vehicle or the carsharing application, competences can mean the knowledge on how to use carsharing or the skillset to be able to drive a car and meanings could reference the perceived value of a car as a status symbol or the cultural embeddedness of sharing. To enable the adoption of a new product or service, it is therefore important to foster shared meanings around its relevance and importance (Hesselgren et al., 2020). As an individual’s behaviour is only the tip of the iceberg of a practice, “the effects of intervening in the behaviour are limited accordingly” (Spurling et al, 2013, p. 8). Rather it is the underlying elements that should be the target of any effort to effect a change in a practice.



Social practices are made of three types of element: material, competence and meaning (Shove et al., 2012, p.23).

| | |
|------------|--|
| Materials | Objects, tools, infrastructures. |
| Competence | Knowledge and embodied skills. |
| Meanings | Cultural conventions, expectations and socially shared meanings. |

Figure 3: The elements constituting a practice (Spurling and McMeekin, 2015, p.79)

Observing these elements will help to understand how the households are currently organising their mobility habits and how much would have to be rearranged to make them compatible with carsharing. Changing behaviours however is complex, as they are embedded in social contexts (Jackson, 2005). When aiming to change practices the notion of a value-action gap can be useful. This concept refers to the sometimes unconscious habits that can complicate rational decisions and the resulting dissonance in the relationship between values and actions (Hobson, 2003). Further, social practices emerge in the interaction between lifestyles and systems of provisions, studying

both is crucial. Systems of provision can thereby either support or obstruct the adoption of a lifestyle. It is therefore important for the organisations that are designing them to have a good understanding of all three elements of the practice as well as related practices so that users can integrate them within their lifestyle.

Social practice theory is therefore about understanding people's perception of their normal ways of doing things and how these routines are developed, maintained, and changed over time (Shove et al., 2007). Taking on a practice perspective can help to imagine what the 'new normal' under inclusion of a new or changed practice could look like and helps us to identify trajectories to its implementation (Spurling et al., 2013). To influence these practice dynamics, Spurling et al. (2013) suggest three intervention framings. These are the recrafting of practices, the substituting of practices and the changing of how practices interlock. The recrafting of practices is focused on changing individual elements which make up practices to make these practices better. Therefore, if we are thinking about the practice of travelling by car, this perspective can help to understand the elements that need to change for transport-poor households to go from car ownership to carsharing, while the overall practice remains travelling by car. Substituting practices instead looks at replacing existing practices with better alternatives that can fulfil similar purposes. This perspective can help to analyse the change from one practice to another. This can be the change from travelling by foot which only allows for a small mobility radius, or travelling by public transport, which in neighbourhoods with poor public transport accessibility can be very inefficient, to travelling by car through the use of carsharing. The changing of how practices interlock explores how interactions between practices can be harnessed to institute change. This is less applicable to the research question and will hence not be applied.

Business model innovation

A business model is a conceptual tool which "describes the design or architecture of the value creation, delivery and capture mechanisms employed" by the firm (Teece, 2010, p. 1991). As such it can help to analyse and innovate on how a firm does business. It is thereby essential to assure the balance between the three components since for-profit enterprises otherwise cannot be expected to stay in operation (Teece, 2018). These components are also represented in the business model canvas, a tool that can be used for describing, analysing, and designing business models which consists of a total of nine building blocks: the key partners, key activities, key resources, value proposition, customer relationships, customer segments, channels, cost structure and revenue streams (Osterwalder and Pigneur, 2010). These building blocks provide a foundation for business model innovation, where configurations in the firm's current business model are undertaken by making changes in one or multiple building blocks to react to opportunities and challenges, ultimately with the goal to support the firm's financial viability. As we are analysing the potential for carsharing providers' business models to be economically viable in transport poor neighbourhoods, various building blocks are touched. For example, a new customer segment is addressed, assuming transport-poor neighbourhoods are currently found to be underserved. Further, value proposition, partnerships, revenue streams and cost structure could all be potential avenues for redesign to make this market segment a profitable one.

Conceptual framework

The previously introduced concepts originate from different branches of literature. However, they will be combined in this research to create a framework that helps to address the research question. Figure 4 shows graphically the linkages between the concepts and actors in play at the different conceptual levels.

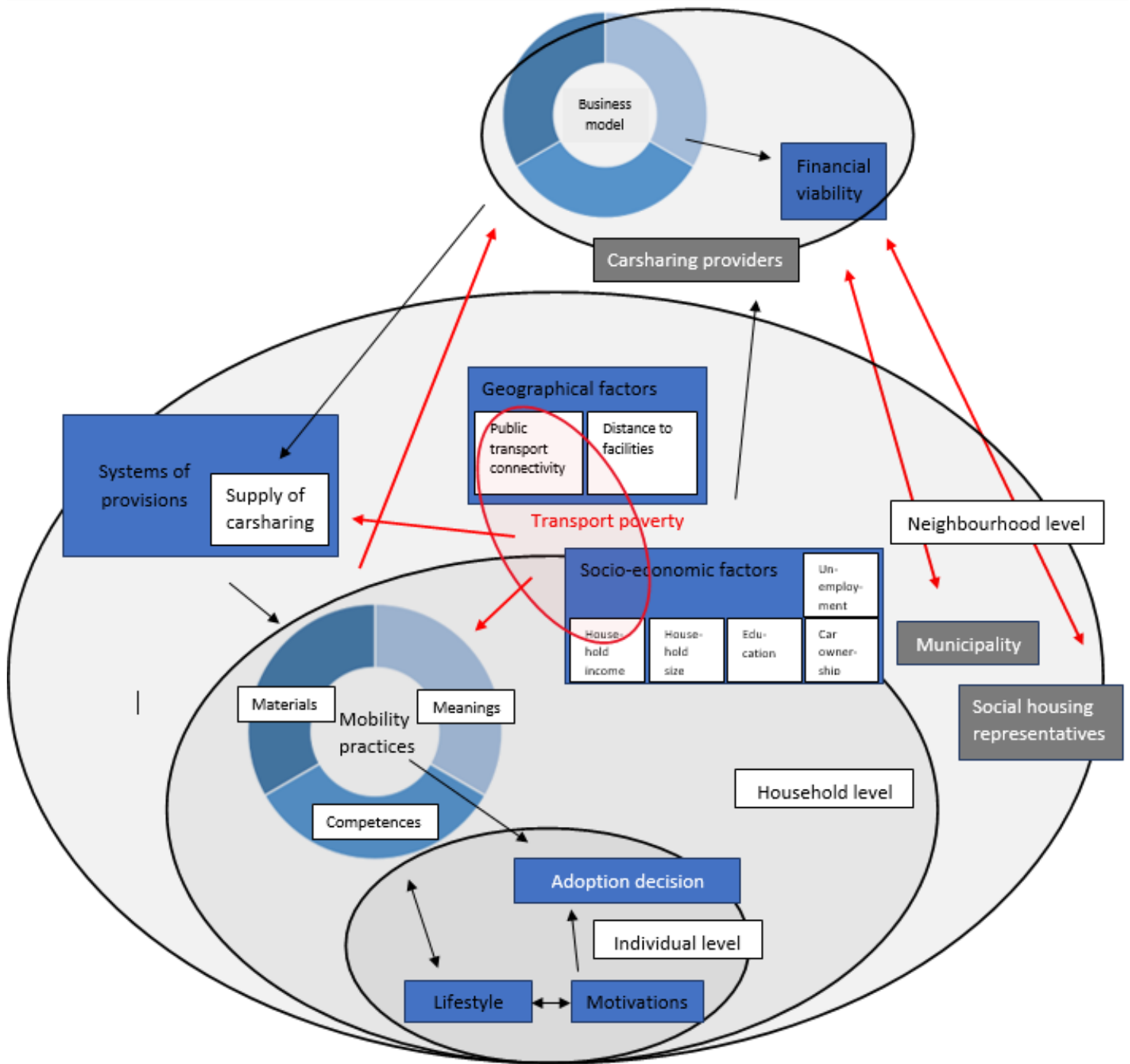


Figure 4: Conceptual framework contextualising the concepts used in this research

The smallest ellipse represents the individual level. It contains the motivations and lifestyle of an individual. The individual forms part of the next conceptual level, the household level. This level is very important for understanding the context of a potential carsharing adoption as it explains the emergence of the household's mobility practices. Practices are formed by the three elements of materials, meanings and competences and materialise through the interaction of an individual's lifestyle on the one hand and the systems of provision that are in place at the neighbourhood level on the other. Another influence on household practices which can be observed at the

neighbourhood level are the geographical factors present, such as the public transport connectivity and the distance to facilities, as well as the socio-economic factors, such as the average household size, income, education level and unemployment rate. The latter are placed at the intersection between the neighbourhood and household level as they are, in this study, observed at the neighbourhood level but describe the household level. Further, two actors, the municipality and social housing representatives are also placed at the neighbourhood level. The neighbourhood is the main level of analysis for this research, as it is the relevant market unit from the carsharing provider's perspective owing to the fact that a stationed carsharing-vehicles will serve those users that are situated within walking distance from its' location. Neighbourhoods are also small enough to be assumed to be relatively homogenous, which allows for the utilization of average values in the data analysis part of the research.

Between the individual and the household level, a box can be found representing the adoption decision which is affected both by the motivations emerging at the individual level and the practices at the household level. Above the set of ellipses, a single ellipse is placed, representing the carsharing providers that are situated outside of the neighbourhood level. Here, interactions can be observed with the neighbourhood level, as geographical and socio-economic factors inform the providers when designing their business model. And also, as these business model decisions affect the systems of provision at the neighbourhood level, by setting the number of vehicles that are supplied. These connections lead to a situation where geographical and socio-economic factors in a neighbourhood indirectly affect the number of vehicles supplied in that neighbourhood. Finally, the elements marked in red signal the relationships this thesis is especially focused on. This is for one, the combination of geographical and socio-economic factors characterising transport poverty and how transport poverty affects the mobility practices of households, but also the systems of provision, especially meaning the shared cars supplied to them. But it also concerns understanding the current mobility practices and showing how this can inform the creation of beneficial value propositions designed by carsharing providers. And third, it looks at how municipalities and social housing associations can take informed measures and cooperate with carsharing providers to support their market expansion to transport-poor neighbourhoods. The success or failure by all stakeholders to contribute to an adequate business model will then as a final step affect the financial viability of the carsharing providers, or in other words the potential for carsharing in transport-poor neighbourhoods.

3. Research design

This paper follows a three-step, mixed-methods approach. In the first, part a regression analysis is performed on the geographical distribution of shared cars, followed by the performance of stakeholder interviews in the second part and the evaluation of results of a survey targeting carsharing users in the last part. Each research step seeks to answer one or multiple sub-questions of the overall research question. The first question is explanatory while the others are of exploratory nature. The sub-questions are the following:

- What is the current state of the system of provision of carsharing in place in transport-poor neighbourhoods in the Netherlands?
- Are there discernible reasons for transport-poor neighbourhoods with below or above-average supply of carsharing?
- What strategies can improve the alignment of the carsharing offer with local mobility practices and needs in transport-poor neighbourhoods?
- What are the motivations for transport-poor individuals to adopt carsharing?
- What are the mobility practices of transport-poor carsharing users like?

Subsequently, the methodology used as well as the results obtained, and the discussion of the results are laid out for each sub-question.

4. Regression analysis

4.1. Methodology

This part deals with the sub-question “What is the current state of the system of provision of carsharing in place in transport-poor neighbourhoods in the Netherlands?”. To better understand the systems of provision of carsharing, the geographical distribution of B2C carsharing is analysed in relation to several socio-economic and geographic variables that correspond to the conditions of transport poverty at the neighbourhood level. These independent variables consist of place-specific factors identified in the literature to affect transport poverty either positively or negatively (Gallerand, 2021). On one hand, these are geographical factors, more specifically the availability of public transport and the distance to facilities. On the other hand, a socio-economic factor is included as well, which is the average household income. Additionally, more socio-economic factors are observed in the study to act as control values, as they are expected to also influence the number of shared cars supplied in the neighbourhood, but also to provide more contextual insights to the analysis. These factors are population and population density as well as the average household size, the share of the population with low education levels, the average number of private cars per household and the percentage of households receiving unemployment benefits. It is expected that population and population density have a positive relationship with the number of shared cars, as higher numbers mean that there are more potential users in the proximity to the shared cars. The remaining control variables however are expected to have a negative relationship with the number of shared cars: carsharing is expected to face more challenges when it comes to supporting the needs of larger households with children. Highly educated people are expected to use innovative products and services more often than those with lower educational attainments. More private car ownership within a neighbourhood is expected to reduce the need for shared cars, and unemployed people have more leisure time allowing which could in theory allow them to opt for public transport.

As was already argued by Meelen et al. (2019), while the use of quantitative methods is not yet very common in sustainability transition studies, it applies well to the objectives of this research as it allows for both the comparison of developments across many localities and for an assessment of the

relative importance of each of the analysed variables. The main aim of this data analysis is to determine whether the neighbourhoods that fit the profile of transport poverty are seeing a lower supply of shared cars when compared to other neighbourhoods. To evaluate this, transport poverty is broken down into multiple variables and their correlation with the number of shared cars available is assessed. It is expected that characteristics of transport poverty correlate negatively with the number of shared cars in the neighbourhoods, building on the following three hypotheses:

Hypothesis 1: The lower the average income within the neighbourhood (associated with more transport poverty), the fewer shared cars are available.

Hypothesis 2: The higher the distance to facilities within a neighbourhood (associated with more transport poverty), the fewer shared cars are available.

Hypothesis 3: The lower the public transport accessibility within a neighbourhood (associated with more transport poverty), the fewer shared cars are available.

In addition to confirming or negating these hypotheses, the analysis also looks for outliers within the set of transport-poor neighbourhoods identified. These outliers can either be under-served neighbourhoods with less carsharing supply than the average, representing the worst practice or well-served neighbourhoods with more carsharing supply than the average, signalling best practice. This determination is further employed as input for the second analytical step of this paper. In this first step however, the regression analysis is performed for 30 municipalities selected based on a purposive sampling approach targeting the largest Dutch cities excluding those with more than 600 000 inhabitants. This means an exclusion of the two largest Dutch cities, Amsterdam, and Rotterdam to limit the data collection to a scope manageable within the time constraints. The cities studied are listed in Table 1.

| Municipality | Population | Municipality | Population |
|---------------------|-------------------|---------------------|-------------------|
| The Hague | 548320 | 's-Hertogenbosch | 155490 |
| Utrecht | 359370 | Zwolle | 129840 |
| Eindhoven | 235691 | Zoetermeer | 125267 |
| Groningen | 233273 | Leeuwarden | 124481 |
| Tilburg | 221947 | Leiden | 124093 |
| Almere | 214715 | Maastricht | 120227 |
| Breda | 184126 | Dordrecht | 119115 |
| Nijmegen | 177359 | Ede | 118530 |
| Apeldoorn | 164781 | Alphen aan den Rijn | 112587 |
| Haarlem | 162543 | Westland | 111382 |
| Arnhem | 162424 | Alkmaar | 109896 |
| Enschede | 159732 | Emmen | 107024 |
| Haarlemmermeer | 157789 | Delft | 103581 |
| Amersfoort | 157462 | Venlo | 101988 |
| Zaanstad | 156901 | Deventer | 101236 |

Table 1: Analysed municipalities and their populations (CBS, 2021)

For these municipalities, as the dependent variable, current data on the vehicles supplied is collected manually from the providers present in the Netherlands. The locations of the shared vehicles are then mapped using a geographic information system (GIS), with the number of cars available in each neighbourhood representing the strength of the system of provision of carsharing in place. For this purpose, the GIS application QGIS is used, which is open-source and freely available

online (QGIS Development Team, 2022). Here, the location of each carsharing vehicle within the 30 relevant municipalities is plotted manually onto a street map of the Netherlands. The map data has been downloaded for free from OpenStreetMap, a project providing an editable geographic database of the world (OpenStreetMap, 2022). The decision on which providers to include is made based on an analysis run by Advier on the size and geographical coverage of carsharing providers in the Netherlands. Based on this knowledge, all Dutch B2C carsharing providers are selected that are present in at least one of the 30 relevant municipalities and have a minimum of 100 cars stationed across the Netherlands. This results in five providers: GreenWheels, MyWheels, ConnectCar, WeDriveSolar and SIXT, of which the first four offer roundtrip services and the last one, SIXT offers a free-floating service.

The information on the locations of vehicles is taken from the websites and mobile applications of the five providers during daytime hours on weekdays in calendar week six of 2022 (GreenWheels, 2022; MyWheels, 2022; ConnectCar, 2022; WeDriveSolar, 2022; SIXT, 2022). Following this approach, a total of 2077 vehicle locations are collected. In most cases, these locations correspond to the fixed parking spots assigned to each vehicle. In the case of the provider MyWheels, some vehicles operate with area permits. This means, that the vehicle can be parked in a predetermined area which encompasses several adjacent streets within a neighbourhood. For these vehicles, the most central location within the permitted area is entered in the GIS, still providing a good approximation of the usual location of the shared vehicles. Lastly, for the provider SIXT which offers a free-floating service, the vehicles neither have fixed parking spots nor area permits. Instead, vehicles can be parked anywhere within the business area, which covers two municipalities relevant for this research - a limited inner-city area of The Hague and a parking space at Utrecht's central station. The locations of these vehicles are plotted in the GIS based on their distribution at one fixed point in time, a Monday morning during the data collection period. This still provides a good representation of the provider's geographical coverage, as vehicles are spread fairly evenly throughout the business area and the unavailability outside the business area can also be depicted accurately.

Using QGIS, the collected data on vehicle locations is then assigned to neighbourhoods using the statistical division at the "buurt" level (term is equivalent to neighbourhood in Dutch). For this purpose, the geospatial data on these boundaries is taken from Statistics Netherlands (CBS, 2019a). This data, as well as that for most other variables, is collected for the year 2019, which is the most recent year for which all but one variable have been freely available online. This is still recent enough to conduct a meaningful data analysis, considering that the variables in question are expected to change rather slowly. The set of variables considered in the analysis can be found in Table 2. They all consider the neighbourhood level. Variables on population, average household size, low-income households, education level, unemployment benefits, private vehicles per household and distances to facilities are taken from the "Kerncijfers wijken en buurten" report provided by Statistics Netherlands (CBS, 2019b). The data on public transport accessibility is taken from the 2018 report of Delta Metropool and is the only variable collected that was not freely available for 2019. It is however fitted to the neighbourhood boundaries of 2019, to enable comparability with the other variables.

| Name | Description | Type | Classification | Relation to transport poverty |
|--------------------|--|-------------|----------------|-------------------------------|
| shared cars | Number of vehicles supplied | Dependent | Count | |
| PTAI | Public transport accessibility | Independent | Continuous | Inverse |
| distance | Distance to facilities | Independent | Continuous | Linear |
| low_income_p | Percentage of low-income households | Independent | Continuous | Linear |
| population | Population | Control | Count | |
| population_density | Population density | Control | Continuous | |
| household_vehicles | Average number of private vehicles per household | Control | Continuous | |
| household_size | Average number of people in household | Control | Continuous | |
| low_edu_p | Percentage of population with low education attainment | Control | Continuous | |
| unemployment_ben_p | Percentage of population receiving unemployment benefits | Control | Continuous | |
| Utrecht, etc. | Municipality dummies | Control | Binary | |

Table 2: Dependent and independent variables at neighbourhood level used in regression analysis

In the following, the different independent variables, as well as the specific data preparation procedures for each variable are described. The municipality dummies will be explained later on.

Public transport accessibility

This variable is based on the public transport accessibility index (PTAI) that provides scores on a 500x500m grid for the entirety of the Netherlands. The score accounts for the frequency of various available transport routes within reach of the location, weighted by the type of transport mode. The maximum distance to public transport stops that are considered are 3,000 meters for train stations, 800 meters for metro stops and 400 meters for bus or tram stops (Delta Metropool, 2022).

Distance to facilities

The distance to facilities is calculated as the average distance of the inhabitants of a neighbourhood from a general practitioner's practice, supermarket, children's day-care, and school. These values were provided separately and averaged during data preparation (CBS, 2019b).

Percentage of low-income households

The percentage of low-income households is calculated based on the target population of private households with a main breadwinner who has an income throughout the year and is not dependent on student grants. The household income is converted to a standardized income using the price index and excluding housing benefits received. It is then converted to the price level of the year 2000 and counted as low when it is less than 9249 euros per year per household (CBS, 2019b).

Average household size

The average household size is calculated as the number of people living in all households within a neighbourhood divided by the number of households in a neighbourhood (CBS, 2019b).

Average number of private vehicles per household

This variable is determined using regional vehicle registration data to identify all vehicles registered within the neighbourhood on January 1st, 2019, then dividing by total households (CBS, 2019b).

Percentage of population with a low education level

The percentage of the population with a low education level is based on the number of people between 15 and 75 years of age for which the highest attained level of education is low. A low education level includes primary education, pre-vocational secondary education, the first 3 years of HAVO/VWO and the entrance course, the former assistant course (MBO1) and practical education (CBS, 2019b). This variable has been converted from an absolute number of people to a percentage by dividing by population numbers.

Percentage of population receiving unemployment benefits

The percentage of population receiving unemployment benefits is based on the number of people receiving payments under the Unemployment Insurance Act, or 'werkloosheidswet' in Dutch (CBS, 2019b). This number is then divided by the population.

Subsequently, all variables are merged into one table using a free software environment for statistical computing called R (R Core Team, 2020). This results in a table with data on 2782 neighbourhoods, with a total of 2077 shared cars between them. After the exclusion of all data points with missing data, this number decreases to 2030 neighbourhoods with 2022 shared cars. Statistical analysis is conducted on the dataset to assure that there are no unexpected values in the data, which is confirmed to be not the case (see Appendix B). Further, correlation analysis shows that moderate correlations exist between the variables, with the highest correlations measured being a negative correlation of -0.56 between the population density and distance to facilities variable and a positive correlation of 0.4 between the average household size and the average number of private vehicles per household. All correlation values are depicted in Figure 5 (tables can be found in Appendix C). These correlations are deemed to be acceptable for performing regression analysis on the variables. The final data set is now analysed using regression analysis in R. For this analysis the population and population density are treated as control variables as they are expected to affect the number of shared cars present within a neighbourhood. They therefore may explain some of the relationships between the independent and dependent variables, an effect which is accounted for by including them as control variables. The variables on household size, low education attainment, unemployment share and the number of private cars per household are analysed to act as control variables on the one hand and provide additional insights into the socio-economic context of carsharing supply on the other.

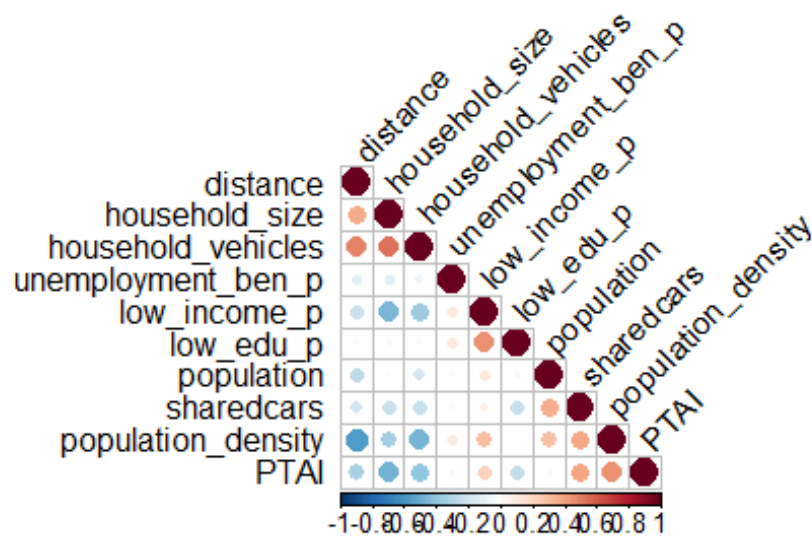


Figure 5: Correlation matrix for all dependent and independent variables

The choice of the regression model is based on the following considerations: First of all, as the dependent variable is a count variable, the conditions for linear regression are not fulfilled, as it requires a continuous dependent variable. A multivariate binary logit model could be used after transforming the dependent variable into a binary variable representing either the availability or unavailability of shared cars in the neighbourhood (Tripepi et al., 2011). However, this would lead to the loss of information, as the number of cars per neighbourhood provides additional depth to the analysis. Therefore, for the best fit, a model is needed which is specifically designed for dependent variables that are count variables. This is the case for the Poisson model and the negative binomial model. The Poisson model works under the assumption of normal dispersion, meaning that the variance of the dependent variable is equal to the mean. With a mean of 0.9961 and a variance of 6.0552 and with a dispersion of 11.58581 the dependent variable is over-dispersed and therefore the model is not a fit. The negative binomial model is the better choice for data with significant overdispersion and is therefore applied for this analysis (Meelen, 2019; Cameron & Trivedi, 2013).

In the following results section, first, the results of the negative binomial regression are provided. In addition to the geographic and socio-economic variables, this model also includes 30 binary dummy variables which are introduced to represent each of the municipalities in the sample acting as control variables. Each dummy can be either 1, showing that the neighbourhood is part of the municipality or 0 if it is not. Including this layer of data allows for better understanding of the contribution that belonging to a certain municipality has in explaining carsharing supply. This effect could be observed for example due to local transport policies and other municipality-specific circumstances that create different conditions for the neighbourhoods belonging to a municipality compared to others. This analysis is then further extended by running a zero-inflated negative binomial regression for which the results are also provided. This decision was taken because the dependent variable contains a large number of data points with a count of zero. More specifically, 65% of the neighbourhoods in the sample have zero shared vehicles. Therefore, running a zero-inflated model assures that the large number of zeros does not skew the results of the regression. This is done by splitting the analysis into two models: first, a logic model is run to estimate the probability of a neighbourhood to be having zero shared cars based on the population density variable. Using this variable allows us to identify the rural areas which are too scarcely populated for carsharing to be profitable. Then, a negative binomial model is run to estimate the counts of shared cars in those neighbourhoods that have several shared cars other than zero. Because of this approach, the zero-inflated model can show what factors influence the availability of B2C carsharing in a neighbourhood and also tell us what factors influence the number of shared cars (Meelen, 2019; Coll et al., 2014). The municipality dummies are not applied in this second model.

4.2. Results

A negative binomial regression with municipality dummies:

| | Estimate | Standard error | Z-value | P-value | Significance |
|--------------------|--|----------------|---------|----------|--------------|
| distance | -7.897e-01 | 1.596e-01 | -4.948 | 7.49e-07 | *** |
| PTAI | 2.581e-03 | 1.184e-03 | 2.180 | 0.029222 | * |
| low_income_p | 8.006e-03 | 6.791e-03 | 1.179 | 0.238452 | |
| population | 1.868e-04 | 1.505e-05 | 12.417 | < 2e-16 | *** |
| household_size | -5.738e-01 | 1.037e-01 | -5.535 | 3.11e-08 | *** |
| low_education_p | -4.125e-02 | 4.965e-03 | -8.308 | < 2e-16 | *** |
| population_density | 3.062e-05 | 9.363e-06 | 3.27 | 0.001075 | ** |
| unemployment_ben_p | -3.381e+00 | 7.054e+00 | -0.479 | 0.631745 | |
| household_vehicles | -1.014e-01 | 1.136e-01 | -0.893 | 0.371953 | |
| Utrecht | 3.574e+00 | 5.886e-01 | 6.072 | 1.26e-09 | *** |
| The Hague | 2.837e+00 | 5.907e-01 | 4.803 | 1.57e-06 | *** |
| Amersfoort | 2.458e+00 | 5.938e-01 | 4.140 | 3.48e-05 | *** |
| Leiden | 2.432e+00 | 5.990e-01 | 4.060 | 4.92e-05 | *** |
| Nijmegen | 2.400e+00 | 6.028e-01 | 3.982 | 6.84e-05 | *** |
| Arnhem | 2.284e+00 | 5.985e-01 | 3.817 | 0.000135 | *** |
| Haarlem | 2.254e+00 | 5.957e-01 | 3.784 | 0.000154 | *** |
| Eindhoven | 2.201e+00 | 5.939e-01 | 3.706 | 0.000211 | *** |
| Zwolle | 2.165e+00 | 6.056e-01 | 3.576 | 0.000349 | *** |
| Delft | 2.042e+00 | 6.030e-01 | 3.387 | 0.000707 | *** |
| Ede | 1.950e+00 | 6.319e-01 | 3.085 | 0.002035 | ** |
| s'Hertogenbosch | 1.945e+00 | 6.080e-01 | 3.199 | 0.001377 | ** |
| Alkmaar | 1.707e+00 | 6.263e-01 | 2.725 | 0.006426 | ** |
| Breda | 1.668e+00 | 6.162e-01 | 2.707 | 0.006785 | ** |
| Groningen | 1.587e+00 | 6.033e-01 | 2.630 | 0.008548 | ** |
| Almere | 1.586e+00 | 6.299e-01 | 2.518 | 0.011811 | * |
| Alphen | 1.557e-01 | 7.687e-01 | 0.203 | 0.839498 | |
| Deventer | 1.506e+00 | 6.349e-01 | 2.373 | 0.017666 | * |
| Zaanstad | 1.438e+00 | 6.422e-01 | 2.239 | 0.025135 | * |
| Maastricht | 1.368e+00 | 6.332e-01 | 2.161 | 0.030728 | * |
| Dordrecht | 1.346e+00 | 6.229e-01 | 2.161 | 0.030688 | * |
| Haarlemmermeer | 1.130e+00 | 6.655e-01 | 1.698 | 0.089477 | |
| Apeldoorn | 1.248e+00 | 6.475e-01 | 1.928 | 0.053899 | |
| Tilburg | 1.116e+00 | 6.082e-01 | 1.835 | 0.066450 | |
| Enschede | 1.057e+00 | 6.485e-01 | 1.630 | 0.103044 | |
| Zoetermeer | 1.012e+00 | 6.946e-01 | 1.457 | 0.144979 | |
| Leeuwarden | -3.238e-01 | 7.695e-01 | -0.421 | 0.673907 | |
| Emmen | -3.336e+01 | 1.035e+07 | 0.000 | 0.999997 | |
| Westland | -3.372e+01 | 8.646e+06 | 0.000 | 0.999997 | |
| Venlo | -6.919e-01 | 6.314e-01 | -1.096 | 0.273188 | |
| Significance codes | 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 1 | | | | |

Table 3: Coefficient estimates for the negative binomial model with dummies

The above results show that two out of three transport-poverty-related independent variables, as well as several control variables and many municipality dummies are significantly correlated with the dependent variable. Taking a closer look at the independent variables it can be said that both the distance to facilities as well as the public transport accessibility are significant at the 0.001 and 0.05 levels respectively and behave as predicted in hypotheses 2 and 3. The distance variable shows a negative relationship with the number of shared cars, which means that the higher the distance to facilities such as schools and supermarkets, the fewer shared cars are available within the neighbourhood. This could owe to the fact that these longer distances lead to a higher dependency on a private car, thereby reducing the need for carsharing. The public transport accessibility shows a positive coefficient, so the lower the public transport accessibility in the neighbourhood, the fewer shared cars are available. This can be reasoned again with a higher dependency on the private car and therefore a reduced need for carsharing. However, it could also signal that the conditions are less conducive to carsharing as multi-modal transport is more difficult. The share of the population disposing over a low income is not significantly correlated with the number of shared cars in this analysis, therefore not supporting the prediction made in hypothesis 1.

Concerning the control variables, the population, household size and low education share variables are all significant at the 0.001 level. They all behave as was expected, with the population number being positively correlated with the number of shared cars, as is the population density, which is significant at the 0.01 level. This means that the more inhabitants a neighbourhood has and the more densely it is populated, the more shared cars are supplied there. This finding supports the assumption that higher population numbers and density are beneficial for carsharing as they mean that more potential customers are situated within proximity of the shared cars (Münzel, 2020). As carsharing vehicles are often accessed by foot this can be a decisive factor for the success of a location. Household size and low education share are negatively correlated with the number of shared cars which signifies that a larger average household size and a larger share of the population with low education attainment both correlate with fewer shared cars being observed in the neighbourhood. For the household size, this can relate to larger households, such as families, owning a vehicle, therefore not relying on the carsharing service. With regards to the low education variable, the results blend in with Roger's theory on the diffusion of innovation where he describes that the earlier adopters of an innovation differ in socio-economic characteristics from the later adopters (Rogers, 2003). This can apply to well-educated individuals who can navigate the complexity of an innovation better and whose social context allows them to gain awareness of the innovation and observe its benefits more easily, leading them to adopt it earlier than those with a lower education status. No significant correlation is observed for the unemployment share and private vehicles variables.

Lastly, for the municipalities dummies it can be noted that there is a large number of municipalities for which the location of a neighbourhood within their boundaries correlates positively with the number of shared cars observed. This can be explained through the significant differences occurring between municipalities in the factors supporting or obstructing carsharing expansion, such as differing transport policies at the municipal level or collaborations in place. The effect is statistically significant at the 0.001 level for ten of the 30 municipalities analysed. The municipality for which this effect is found to be the strongest is Utrecht, followed by The Hague, Amersfoort, Leiden, Nijmegen, Arnhem, Haarlem, Eindhoven, Zwolle, and Delft. Accordingly, regardless of the other variables observed in this analysis, the neighbourhoods situated in the municipality of Utrecht can be expected to have a larger number of shared cars than the neighbourhoods in other municipalities. The municipalities for which a negative correlation is identified are Venlo, Emmen, Westland, and Leeuwarden. This means that neighbourhoods are found to have fewer shared cars than similar

neighbourhoods in other municipalities. As this model is corrected for the belonging to a municipality, the socio-economic and geographic variables shown to be significant are not distorted by the local factors in place in individual municipalities.

A zero-inflated negative binomial regression without dummies:

| | Estimate | Standard Error | Z-value | P-value | Significance |
|--------------------|--|----------------|---------|----------|--------------|
| Intercept | 5.955e-01 | 1.388e+00 | 0.429 | 0.668 | |
| population_density | -5.541e-04 | 8.845e-05 | -6.264 | 3.74e-10 | *** |
| Significance codes | | | | | |
| | 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 1 | | | | |

Table 4: Coefficient estimates for the zero-inflated model part

Table 4 shows the zero-inflated part of the zero-inflated negative binomial regression model. It can be seen that population density is a good predictor for the excess zeros within the dataset with a statistical significance of 0.001. The coefficient can be interpreted to say that the higher the population density in a neighbourhood is, the lower the probability for the neighbourhood to have a count of zero shared cars. This confirms the assumption that the more rural neighbourhoods within the dataset, which can typically be characterised by a lower population density, are underserved by carsharing, and often do not see any supply of shared cars at all. By accounting for these zeros in a separate part of the model, the results observed in the subsequent count model part are assured to not be skewed by the excess zeros in the rural neighbourhoods.

| | Estimate | Standard Error | Z-value | P-value | Significance |
|--------------------|--|----------------|---------|----------|--------------|
| Intercept | 591.3 | 297.5 | 1988 | 0.046832 | * |
| PTAI | 13.78 | 2.067 | 6667 | 2.61e-11 | *** |
| low_income_p | 25.46 | 8.922 | 2853 | 0.004331 | ** |
| distance | -551.4 | 325.8 | -1692 | 0.090583 | |
| population | 0.2624 | 0.04176 | 6283 | 3.32e-10 | *** |
| population_density | 0.04751 | 0.002949 | 16111 | < 2e-16 | *** |
| low_education_p | -62.53 | 5.909 | -10582 | < 2e-16 | *** |
| unemployment_ben_p | -26030 | 8303 | -3135 | 0.001721 | ** |
| household_vehicles | -323.2 | 154.4 | -2094 | 0.036265 | * |
| household_size | -131.7 | 126 | -1046 | 0.295728 | |
| Significance codes | | | | | |
| | 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 1 | | | | |

Table 5: Coefficient estimates for the count model part

The count model results in Table 5 show that after accounting for the excess zeros, two of the three transport-poverty-related independent variables and most of the control variables show a significant correlation with the number of shared cars within a neighbourhood. Regarding the independent variables, it can be said that public transport accessibility is still positively correlated, as is the case in the earlier negative binomial analysis, this time however at the 0.001 level. The distance to facilities variable, which was significantly positively correlated in the negative binomial regression, is however not significant in this analysis. This points to the effect of the zero-inflated part of the model accounting for the more rural neighbourhoods in the data set and therefore likely disposing of the neighbourhoods with the largest distances to facilities. Conversely, the low-income share of the population, which was insignificant in the earlier analysis, is now significantly positively related at the 0.01 level. This means that the larger the share of the population receiving a low income, the

higher the number of shared cars available in the neighbourhood. This contradicts the prediction formulated earlier in hypothesis 1, where it was supposed that a lower average income within the neighbourhood, would mean that fewer shared cars are supplied. The reasoning behind this assumption was that a higher income would allow for more funds to be spent on travel, therefore allowing users to demand more carsharing. The fact, that in reality the opposite effect can be observed, suggests that carsharing in the Netherlands is indeed attractive for low-income user groups. This stands in contrast with findings by Petzer et al. (2021) that carsharing which is offered through commercial providers in the Netherlands is largely limited to serving user groups with higher income in order to maintain profitability.

Looking at the control variables, population, population density and the share of the population with low education are all significant at the 0.001 level and behave as predicted and as observed previously in the negative binomial analysis. In contrast to this previous analysis stand the results for the unemployment variable, the private vehicles per household and the household size. The share of unemployment and vehicles per household are not significant in the previous analysis. However, here they are significantly negatively correlated with the number of shared vehicles at the 0.01 and 0.05 level respectively. For the share of unemployment, that means that the higher the share of unemployment is in a neighbourhood's population, the fewer shared cars can be found there. This supports the interpretation that unemployed people have more time to opt for public transport more easily, therefore being less inclined to spend money on carsharing. Additionally, the more private cars a household within a neighbourhood owns on average, the fewer shared cars can be found there. This is logical, as more private cars will reduce the need and the demand for shared cars. Lastly, the household size is found to be significant in the previous negative binomial analysis and is insignificant here. This can again be due to the larger household sizes being a common occurrence in the rural neighbourhoods of municipalities, which in this analysis have been mostly excluded by running the zero-inflated part of the model.

Residual analysis

To confirm whether the models are a good fit for the data and to encounter interesting cases a residual analysis can be helpful. In the following, this analysis is separately conducted for both models. The results are described in more detail for the zero-inflated negative binomial model to be able to go in-depth on the largest positive and negative residuals found and provide a basis for further analysis to build on.

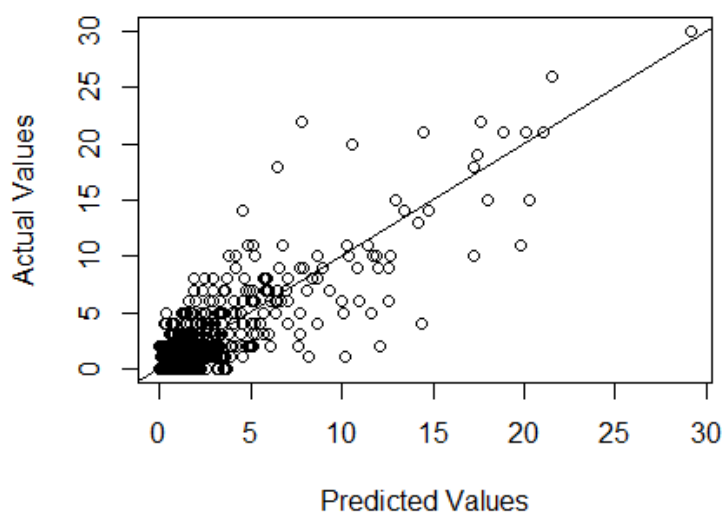


Figure 6: Predicted and actual number of shared cars in the negative binomial regression model

When plotting the values predicted by the negative binomial regression model with the actual values for the number of shared cars per neighbourhood (Figure 6), two things stand out. First of all, the data points are distributed in proximity along the regression line. This signals a good model fit (Stephenson, 2005). This finding is confirmed by studying the individual residuals between the fitted values and actual values for this model. Most residuals are small with the largest positive residual, measured in a neighbourhood where the observed value was larger than the predicted value, being 14.10 and the largest negative residual, measured in a neighbourhood where the predicted value exceeded the observed value, being -10.29. Secondly, it can be noted that the data points are clustered around the low values, especially the zero values. This shows once more that the earlier decision to consult a zero-inflated model is justified.

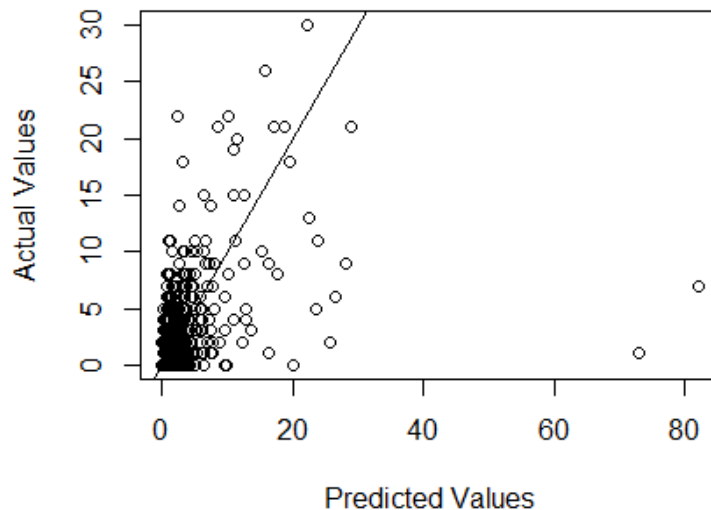


Figure 7: Predicted and actual number of shared cars in the zero-inflated negative binomial regression model

Looking at the predicted and actual values for shared cars in the zero-inflated negative binomial model (Figure 7) most of the data points are still distributed around the regression line, similar to the distribution found in figure 4. However, some more obvious outliers can also be found: two data points with high predicted but low actual values displayed on the far right of the figure. They are the neighbourhoods of d’Oude Morsch in Leiden and Binnenstad-Zuid in Groningen. It is striking that both of them have received very large predicted values for carsharing supply, in fact, the largest two predictions in the entire dataset, but in reality, they experience numbers of shared cars that lie far beneath that. This discrepancy in the model prediction likely occurs because of the extremely high public transport accessibility of the neighbourhoods which are both situated in the city centre. D’Oude Morsch is the neighbourhood with the highest public transport accessibility score in the entire dataset, while Binnenstad-Zuid follows closely in the 8th spot. High public transport accessibility is usually associated with more shared cars as multi-modal mobility becomes easier to achieve and households rely less on private cars. However, it can be assumed that once a certain point is reached users do not perceive a need for using shared cars anymore, as travelling with public transport becomes so convenient. This could be the reason that the model is overestimating the supply of shared cars in such neighbourhoods with very high public transport accessibility. The full data on the largest positive and negative outliers for the zero-inflated negative binomial regression can be found in Appendix D.

In the following, Tables 6 and 7 show those neighbourhoods with clear characteristics of transport-poverty, for which the largest positive and negative residuals were identified based on the zero-

inflated negative binomial regression. This is done to recentre the focus around the research topic which addresses carsharing in transport-poor neighbourhoods and to allow for the sampling of interesting cases to analyse further in the subsequent qualitative part of the research. The transport-poor neighbourhoods are filtered out systematically using the following method: Scores between 0 and 2 are given to each neighbourhood for each of the three variables linked to transport poverty (share of low-income population, public transport accessibility and distance to facilities). These scores are based on the measured value for each neighbourhood and how it stands in relation to the other neighbourhoods in the data set. A value equal to or beneath the mean is scored 0, a value above the mean but below the fourth quantile is scored 1 and a value in the fourth quantile is scored 2. For intuitive interpretation, this scale is inverted for the public transport accessibility, as it is the only variable where lower values are attributed to transport poverty. Accordingly, values equal to or above the mean are scored 0, values below the mean but above the first quantile are scored 1 and values within the first quantile are scored 2. These scores are colour-coded in the tables, with orange corresponding to 2, yellow to 1 and green to 0, and are finally summed up for each neighbourhood with higher scores signalling conditions most conducive to transport poverty. Neighbourhoods with high residuals are to be printed in the table only if they score a minimum of three points for transport poverty, the maximum being 6 points. Additionally, any neighbourhoods with less than 1000 inhabitants are excluded, as they are too small to deliver representative results and will not be considered as sample neighbourhoods for the qualitative part. Lastly, the regression model for which results are printed here is not considering the municipality dummies, so the following tables show neighbourhoods that do especially well or poorly on a national scale.

| Name | Shared cars | Residuals | Population | Population density | Household size | Unemployment benefits | Private vehicles | Low education | Low income | Public transport accessibility | Distance | Transport poverty |
|--|-------------|-----------|------------|--------------------|----------------|-----------------------|------------------|---------------|------------|--------------------------------|----------|-------------------|
| Utrecht, Lunetten-Zuid | 22 | 19.831 | 7125 | 3486 | 2 | 0.014035 | 0.7 | 15.85965 | 13.3 | 16.9711 | 0.625 | 3 |
| The Hague, Rond de Energiecentrale | 14 | 11.33408 | 6250 | 12535 | 1.8 | 0.0144 | 0.5 | 22.72 | 14.1 | 12.3259 | 0.325 | 3 |
| Utrecht, Science Park | 7 | 5.341938 | 3040 | 837 | 1.1 | 0.003289 | 0.1 | 1.31579 | 19.3 | 14.65473 | 0.925 | 5 |
| Utrecht, Geuzenwijk | 6 | 5.071118 | 3830 | 12957 | 1.9 | 0.015666 | 0.6 | 27.67624 | 15.4 | 14.19677 | 0.525 | 3 |
| Utrecht, Schepenbuurt, Cartesiusweg e.o. | 5 | 4.846802 | 1305 | 1224 | 2.2 | 0.015326 | 0.9 | 16.09195 | 2.8 | 17.1864 | 0.975 | 3 |
| Utrecht, Terwijde-West | 6 | 4.752411 | 5110 | 5830 | 2.7 | 0.011742 | 0.1 | 18.19961 | 5.6 | 18.3436 | 0.875 | 3 |
| The Hague, Heesterbuurt | 8 | 4.515735 | 6820 | 16632 | 1.8 | 0.019062 | 0.5 | 20.96774 | 11.8 | 13.76341 | 0.375 | 3 |
| Nijmegen, Hengstdal | 7 | 4.479052 | 6710 | 7984 | 1.7 | 0.017884 | 0.7 | 18.03279 | 12.6 | 16.4555 | 0.525 | 3 |
| Utrecht, De Meern-Noord | 5 | 4.32804 | 5570 | 3811 | 2.7 | 0.012567 | 1.1 | 17.05566 | 3.3 | 10.09802 | 1 | 3 |
| Utrecht, Halve Maan-Noord | 5 | 4.292074 | 1710 | 9206 | 1.9 | 0.017544 | 0.5 | 20.46784 | 15.8 | 15.23569 | 0.5 | 3 |
| Ede, Enka | 4 | 3.791641 | 1820 | 1680 | 2.8 | 0.010989 | 1.1 | 9.340659 | 2.5 | 9.074752 | 1.4 | 3 |
| Haarlem, Stedenbuurt-west | 3 | 2.459414 | 2655 | 10836 | 2 | 0.007533 | 0.8 | 30.50847 | 14.8 | 5.069673 | 0.425 | 4 |
| Utrecht, Zuilen-Noord | 3 | 2.362825 | 3820 | 5320 | 2.1 | 0.015707 | 0.8 | 19.10995 | 8.5 | 11.42222 | 0.8 | 3 |
| Eindhoven, Grasrijk | 3 | 2.349714 | 5835 | 4567 | 2.6 | 0.011997 | 1.1 | 15.25278 | 0.3 | 2.785569 | 1.3 | 4 |
| The Hague, De Bras | 3 | 2.346483 | 5850 | 6785 | 3.1 | 0.011966 | 1.2 | 20.34188 | 5.5 | 0.976135 | 1.1 | 4 |

Table 6: 15 transport-poor neighbourhoods with largest positive residuals for zero-inflated negative binomial regression without municipality dummies (inhabitants > 1000)

Table 6 reveals that there are several transport-poor neighbourhoods where the supply of shared cars exceeds model predictions considerably, showing that carsharing can indeed be an option for these areas experiencing transport poverty. What immediately stands out, is that eight of the fifteen transport-poor neighbourhoods which are exceeding model predictions, most are situated in the

municipality of Utrecht. This supports the findings of the negative binomial model, where the municipality dummy for Utrecht shows the strongest positive correlation, signalling that neighbourhoods in the municipality do better than those in other municipalities with otherwise similar circumstances. Other municipalities present in the table are The Hague, Nijmegen, Ede, Haarlem, and Eindhoven.

The neighbourhood with the largest positive residual of all neighbourhoods in the dataset is Lunetten-Zuid, with a predicted value of 2.17 and a measured number of 22 shared cars. When analysing Lunetten-Zuid for its conditions relating to transport poverty it can be found that there is a very high share of the low-income population in the neighbourhood and the public transport accessibility is low. This makes Lunetten-Zuid a very interesting case to further analyse in the qualitative part of this study to uncover the reasons behind its' outstanding performance. Another well-performing neighbourhood which might be interesting for the next part of the study is the neighbourhood of Rond de Energiecentrale in The Hague, which similarly hosts a very high share of low-income inhabitants and has low public transport accessibility. Additionally, Utrecht Science Park is shown to also have a high residual value combined with an especially high transport-poverty value. The location of the campus of Utrecht University in this neighbourhood serves as a good explanation for this outlier. As hypothesised before and confirmed in the regression analyses, higher education levels lead to faster adoption of innovative products and services, likely benefitting carsharing services in this area and leading to a higher supply of shared cars. While interesting, this can be seen as a niche case with limited applicability to the research topic, making it less interesting for the qualitative analysis.

| Name | Shared cars | Residuals | Population | Population density | Household size | Unemployment benefits | Private vehicles | Low education | Low income | Public transport accessibility | Distance | Transport poverty |
|---|-------------|-----------|------------|--------------------|----------------|-----------------------|------------------|---------------|------------|--------------------------------|----------|-------------------|
| Zoetermeer, Oosterheem-Noord-Oost | 0 | -9.51627 | 15915 | 7518 | 2.6 | 0.01508 | 1.1 | 20.48382 | 5.8 | 3.023481 | 1.2 | 4 |
| Zoetermeer, Meerzicht-West | 0 | -2.41315 | 9305 | 6590 | 2.2 | 0.011822 | 0.9 | 23.10586 | 9.4 | 8.411589 | 0.8 | 3 |
| Haarlemmermeer, Hoofddorp Floriande West | 0 | -2.41275 | 10255 | 6184 | 2.7 | 0.014627 | 1.2 | 19.01511 | 3.7 | 2.612873 | 0.825 | 3 |
| Breda, Prinsenbeek | 0 | -2.36973 | 10980 | 3050 | 2.4 | 0.01275 | 1.3 | 17.21311 | 2.6 | 3.891363 | 0.8 | 3 |
| The Hague, Dreven en Gaarden | 2 | -2.3384 | 10820 | 10873 | 2.1 | 0.013863 | 0.6 | 32.53235 | 19.1 | 13.05429 | 0.5 | 3 |
| Nijmegen, Hatert | 1 | -2.24899 | 10175 | 6905 | 1.7 | 0.014742 | 0.6 | 28.40295 | 16.8 | 6.879467 | 0.575 | 3 |
| The Hague, Venen, Oorden en Raden | 0 | -1.94893 | 8730 | 10760 | 2.1 | 0.014891 | 0.6 | 37.22795 | 22.9 | 8.417283 | 0.425 | 3 |
| The Hague, Morgenstond-West | 1 | -1.93 | 7505 | 12346 | 2.2 | 0.011992 | 0.7 | 25.18321 | 13.5 | 14.20081 | 0.375 | 3 |
| Haarlemmermeer, Nieuw-Vennep Getsewoud Zuid | 0 | -1.63502 | 9030 | 7875 | 2.8 | 0.013289 | 1.2 | 19.2691 | 3.1 | 2.06623 | 1.125 | 4 |
| Groningen, Beijum-West | 0 | -1.59306 | 6115 | 5201 | 2 | 0.016353 | 0.7 | 17.33442 | 12.8 | 7.976871 | 0.575 | 3 |
| Emmen, Rietlanden | 0 | -1.29935 | 9440 | 3479 | 2.4 | 0.018008 | 1.2 | 19.49153 | 5.4 | 3.927085 | 0.975 | 4 |
| Enschede, Drienerveld-Universiteit | 0 | -1.20098 | 2605 | 969 | 1.1 | 0 | 0.1 | 0.767754 | 13.3 | 6.687298 | 1.125 | 5 |
| Emmen, Bargeses | 0 | -1.1748 | 8980 | 3679 | 2 | 0.017817 | 0.9 | 25.16704 | 12.6 | 5.307885 | 1 | 5 |
| Nijmegen, Lent | 3 | -1.12035 | 11175 | 1993 | 2.5 | 0.015213 | 0.1 | 12.34899 | 5.5 | 10.20494 | 0.875 | 3 |
| Zaanstad, Poelenburg | 1 | -1.088714 | 8675 | 8594 | 2.4 | 0.014985591 | 0.8 | 31.1239193 | 17.5 | 12.75275036 | 0.425 | 3 |

Table 7: 15 transport-poor neighbourhoods with largest negative residuals for zero-inflated negative binomial regression without municipality dummies (inhabitants > 1000)

Looking at the largest negative residuals of the zero-inflated model for transport-poor neighbourhoods (table 7), the mix of municipalities changes. Utrecht is now only present once.

Instead, neighbourhoods in Zoetermeer, Haarlemmermeer, Breda, The Hague, Nijmegen, Groningen, Emmen and Enschede are found. It also becomes clear that most of the largest negative residuals in transport-poor neighbourhoods are found where the supply of shared cars is 0. With a predicted number of shared vehicles of 9.52 compared to an observed number of zero cars and strong characteristics of transport poverty, the neighbourhood of Oosterheem-Noord-Oost in Zoetermeer would be an interesting case for the qualitative part of the research. Another insight from the analysis is that as many as three transport-poor neighbourhoods from the municipality of The Hague are found to have some of the largest negative residuals, therefore showing that while overall carsharing supply is comparably higher than in most of the other sample municipalities, the city might be underperforming when it comes to carsharing supply in its transport-poor neighbourhoods.

4.3. Discussion

A strong correlation is detected between the number of shared vehicles available in a neighbourhood and several socio-economic and geographical variables associated with transport poverty. This correlation is mostly in line with the previously stated hypothesis that the presence of conditions of transport poverty is connected to a lower availability of shared cars within a neighbourhood. The independent variables for which this is found to be true are the public transport accessibility, and the distance to facilities. These results can be interpreted to say that the lower the public transport accessibility is in a neighbourhood, the lower is also the supply of shared vehicles. Similarly, the longer the distances to facilities, the lower the supply of shared cars. Both of these correlations contribute to a current situation where carsharing supply is disproportionately low in transport-poor neighbourhoods in the Netherlands – a situation which helps to reinforce the structures of transport poverty and social exclusion rather than to relieve them. On the other hand, the share of the population receiving a low income is found to have a different relationship to the number of shared cars than was expected. It was expected that more low-income inhabitants would mean fewer shared cars, however, the opposite is the case: regression analysis reveals that the higher the share of the low-income population in a neighbourhood, the more shared cars are supplied. A finding which suggests that at least in the Netherlands, carsharing is already a service which suits the needs and manages to capture the demand of some low-income users. The main challenge for carsharing providers to address transport-poor neighbourhoods might therefore not be the low-income population, but rather the remoteness, manifesting itself in lower public transport accessibility and larger distances to facilities and leading to fewer possibilities for multi-modal mobility.

This is also supported by the strong correlation between the population density and the neighbourhoods with counts of zero shared vehicles, showing that rural neighbourhoods with low population density often are not served by carsharing at all. Additionally, with regards to the sheer number of neighbourhoods with zero shared vehicles, it is also striking that the majority of neighbourhoods still do not see any carsharing supply at all. With 65% of neighbourhoods in the sample not currently served by carsharing, the question arises what the expansion strategy of providers will look like. Will the supply in transport-poor neighbourhoods catch up naturally in the course of further expansion or will other neighbourhoods continue to be prioritised? These questions cannot be answered by looking at the current data but are addressed in the qualitative part of this research. But there are more factors that may influence the supply of shared vehicles in a neighbourhood. The analysis of the municipality dummies shows that there are indeed municipalities that are performing stronger and weaker than others as a whole. On a neighbourhood level, this means that a neighbourhood which is situated in Utrecht, the best performing municipality, is likely to have a higher supply of shared cars than a neighbourhood in another

municipality which otherwise has very similar socio-economic and geographical characteristics. This can be attributed to factors such as local regulations and supportive policies in place at the municipal level – making a strong argument for also considering these measures when aiming to improve carsharing supply in transport-poor neighbourhoods.

The results gained from this regression analysis provide interesting insights and deliver great starting points for further in-depth analysis of the factors influencing carsharing supply in the subsequent qualitative interviews. These interviews are aimed at a purposeful sample of neighbourhoods, of which the majority are over- and under-achieving transport-poor neighbourhoods. By providing the subsets of transport-poor neighbourhoods with the largest positive and negative residual values in the dataset, an input is created which can inform this sample selection. Besides that, the most important insight gained from the residual analysis is that there are indeed many transport-poor neighbourhoods where the actual supply of shared cars is exceeding model predictions. This shows that carsharing can be a viable mobility alternative also in transport-poor neighbourhoods and that there are neighbourhoods where this can already be seen today. An example of this is Lunetten-Zuid in Utrecht, a municipality that itself, should be studied further to better understand the drivers behind its outstanding performance when it comes to carsharing supply in transport-poor neighbourhoods.

Adopting a broader perspective though, the current state of carsharing coverage in the Netherlands with regards to transport-poor neighbourhoods is found to be unsatisfactory. While neighbourhoods with a higher percentage of low-income inhabitants see a good supply of shared cars, the addition of low public transport connectivity and long distances to facilities leads shared car supplies to decline drastically. This holds true even when focusing on urban neighbourhoods by systematically excluding those neighbourhoods with a low population density. Lastly however, it should be said that regardless of transport poverty, the supply of shared cars is still relatively low across all municipalities in the sample. The best performing municipality, Utrecht, has a total of 685 shared cars, compared to 105,410 private passenger cars registered in 2020 (Gemeente Utrecht, 2021). Two of the sample neighbourhoods, Westland and Emmen do not see any B2C shared vehicles at all. The total supply of shared cars should be expected to increase exponentially in the coming years, if it is to move from serving innovators and early adopters to serving the majority of potential consumers.

The reliability of this quantitative analysis is high. All data used is available online and the regression can therefore easily be replicated. The data used for the independent variables are sourced from renowned statistical institutions sampling the entire population. The dependent variable can also be extracted from online sources, however as it was sourced from providers' websites showing the stock at one point in time, they might only be approximately replicated once supply changes have occurred. A high validity is achieved with multiple measures. First of all, the large sample size is beneficial as it can approximate the entire population more closely than a more limited sample. To obtain a full dataset several data points are excluded from the analysis when information on their values for the independent variables is not available. In total, this concerns 25.34% of neighbourhoods, but only 3.13% of shared cars. This can be seen to further support the final results, as CBS, the source for most of the independent variables used does not provide data on some of the variables, such as the percentage of low-income households, for neighbourhoods with low numbers of individual households (CBS, 2019b). Therefore, many of the excluded neighbourhoods can be assumed to have a very low population number and population density, characteristics which this analysis has shown to be negatively correlated to the supply of shared cars. Further, the geographic delineation of the data points studied is done at a very small scale leading to more representative values for each neighbourhood observed. Additionally, the use of control variables limits the

influence of confounding variables that can skew the results of the regression. And running several models helps to assure that both the excess zeros in the dataset and the varying local conditions within the municipalities do not skew the results. Lastly, the encountered results align well with the results that were expected based on the theory. The only variable which stands in contradiction with expectations is the share of the population disposing of a low income: In the zero-inflated negative binomial model, this variable correlates positively with the number of shared cars meaning that the larger the share of the low-income population the more shared cars are offered. While this was not anticipated, the results can be interpreted positively in the context of this study.

One shortcoming of this approach is that supply of carsharing vehicles is considered per neighbourhood, thereby not measuring those vehicles which might be close-by and within walking distance in adjacent neighbourhoods. Also, as is typically the case when it comes to regression analyses, is that correlation is not synonymous with causation. This part of the study successfully points out that the number of shared cars changes between neighbourhoods in a way that is correlated with changes observed in factors related to transport-poverty. The possibility that the number of shared cars available causes the other variables to change can be neglected, as in the present moment carsharing is still developing in a niche and the relatively low user numbers in relation to the total population mean that it would not be able to significantly affect the independent variables observed here. The use of control variables as well as the high significance levels found for the regression results however, signal a high correlation between the variables that point towards a high likelihood for causation. While this question cannot be sufficiently answered with a quantitative analysis it provides a basis for the qualitative part of this study that is better suited to draw such conclusions.

5. Interview analysis

5.1. Methodology

This part of the research focuses on two sub-questions which are answered in a series of expert interviews. The first question is a continuation of the previous quantitative part of the research and asks if there are discernible reasons for transport-poor neighbourhoods with below or above-average supply of carsharing. The second question is broader as it seeks to understand what strategies can improve the alignment of the carsharing offer with local mobility practices and needs in transport-poor neighbourhoods. The approach used to answer these questions is qualitative and aims to study a range of transport-poor neighbourhoods with different carsharing availability. To delineate a manageable scope three municipalities are purposefully sampled, for each of which a subset of their neighbourhoods is addressed in the interviews.

First, as a preparative step for this part of the research, the sample selection is conducted. Three Dutch municipalities from within the previous sample of thirty are selected. These municipalities are chosen using a purposive sampling approach. There are three criteria utilized in this process. First, the municipalities need to have transport-poor neighbourhoods which embody interesting scenarios of carsharing supply, meaning those which perform especially well or poorly based on the previous analysis. Secondly, the municipalities need to currently see some carsharing supply. This means that there needs to be at least a small number of shared vehicles available in some of the neighbourhoods within the municipality. This condition is important to assure on one hand, that the interviewees will have basic knowledge about the carsharing service and on the other hand, that comparisons can be drawn between neighbourhoods where carsharing vehicles are supplied and where they are not. Lastly, the third criterium is that the three municipalities should be distinct in their characteristics. This is crucial for broadening the perspective which can be gained through the

interview process, allowing for a richer analysis of the factors playing a role in different municipal contexts. According to these three criteria and based on the residual analysis resulting from the quantitative part of this research, the collected data on the location of carsharing vehicles and supplementary desk research, three municipalities are selected. These municipalities are Utrecht, The Hague and Enschede. In the following, they are briefly described, as are the reasons for why they are particularly interesting cases for this study. For each municipality, it is also described which neighbourhoods the interviews will put a particular focus on. These three neighbourhoods are selected for their relevance to the research focus of this study. All of them are neighbourhoods found in the previous analysis to be transport poor. Apart from this common denominator, the sample neighbourhoods show diverse characteristics.

Utrecht

Utrecht is selected as it is the best-performing municipality within the sample. With 685 shared vehicles spread through nearly all of its' neighbourhoods, the municipality has the largest carsharing supply within the previous sample of 30 municipalities. Based on the analysis of the municipality dummies, Utrecht is also the municipality with the strongest positive correlation between the belonging of a neighbourhood and the number of shared vehicles. This signals that there are factors at play at the local level which create a beneficial situation for carsharing to thrive, such as transport policies. When looking at the residual analysis, Utrecht stands out as the municipality with the largest number of over-achieving transport-poor neighbourhoods, that have more shared cars as predicted by the model. In 2021, between all Utrecht neighbourhoods an average of 7% of households used carsharing and 58% of households owned at least one car (Gemeente Utrecht, 2021b). Utrecht is currently applying a parking permit scheme, however, the three sample neighbourhoods are located outside the perimeter (Gemeente Utrecht, 2022). Figure 8 below shows a map of Utrecht, including the locations of all shared vehicles mapped in the previous step. It also shows the transport-poverty scores of the neighbourhoods and marks the locations of the neighbourhoods considered in the sample.

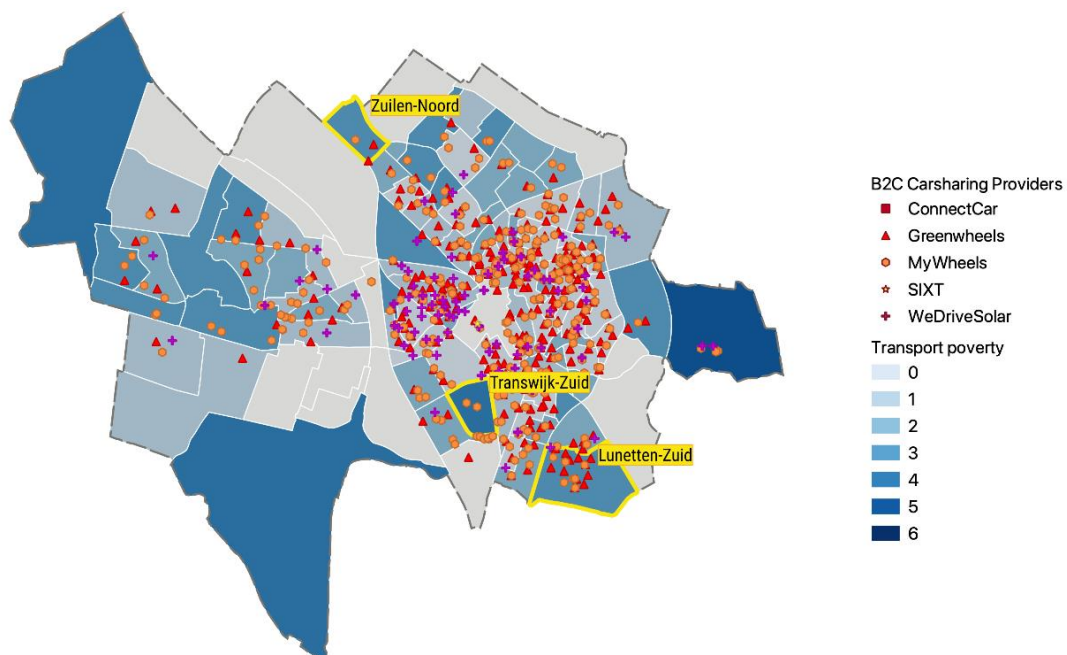


Figure 8: Transport poverty, locations of shared cars and sample neighbourhoods in Utrecht

The neighbourhood with the biggest positive residual in the dataset is the Utrecht neighbourhood of Lunetten-Zuid. Based on the collected data this neighbourhood has a transport-poverty score of three, with a large share of the low-income population and low public transport accessibility, yet it sees a relatively large number of shared cars compared to other transport-poor neighbourhoods in the sample. It is a residential neighbourhood in the south-eastern periphery of Utrecht, which has been built mostly in the 1970s and 1980s (Lauteslager, 2022) utilizing an urban planning approach called “Bloemkoolwijk” (in English: cauliflower neighbourhood) (Klimaat-effectatlas, 2021). 49% of the apartments in Lunetten-Zuid are owned by housing corporations and the average gross income in the neighbourhood is EUR 27,300 (AlleCijfers, 2022a).

The next neighbourhood in the Utrecht sample is Zuilen-Noord. This neighbourhood also has a transport-poverty score of three, with a relatively high share of the low-income population, low public transport accessibility and long distances to facilities. There are few shared vehicles available in this neighbourhood, still exceeding very low model predictions. This neighbourhood is situated on the northern outer borders of Utrecht. The real estate in this area is diverse, with large portions built between 1900 and 1970 and between 2000 and 2020 (AlleCijfers, 2022b). The neighbourhood has both low-income housing in the “volkswijk” style, with small, directly adjacent houses, but also residential villas (Klimaat-effectatlas, 2021). 40% of apartments are owned by housing corporations and the average gross income is EUR 27,000 (AlleCijfers, 2022b).

Lastly, the neighbourhood of Transwijk-Zuid is located just south of the city centre, but with four points still has one of the highest transport-poverty scores observed in the municipality. It has a high share of low-income population and long distances to facilities. It sees very few shared cars, with the model predicting no shared cars at all. Large areas of this neighbourhood are covered by a park and old industrial buildings (Klimaat-effectatlas, 2021). 68% of the apartments in this neighbourhood are owned by housing corporations. While some of the housing was built in the 50s and 60s, most was built after the year 2000. The average gross income is EUR 26,900 (AlleCijfers, 2022c).

The Hague

The municipality of The Hague is interesting for this study as it also has a substantial supply of shared cars. In the analysis of municipality dummies, it follows Utrecht in the second spot with a substantial positive correlation between the location of a neighbourhood within the municipality and its' number of shared vehicles. With a total of 393 carsharing vehicles, however, it still stays far behind Utrecht, which has fewer inhabitants (CBS, 2021). This is also underlined by the larger number of neighbourhoods where carsharing is not available at all. With regards to the residual analysis conducted, an interesting finding about The Hague is that it has both transport-poor neighbourhoods with some of the largest positive residuals as well as neighbourhoods with some of the largest negative residuals. These significant differences between neighbourhoods make The Hague an interesting case to analyse. Figure 9 shows the three sample neighbourhoods which are considered for this municipality.



Figure 9: Transport poverty, locations of shared cars and sample neighbourhoods in the The Hague

The first neighbourhood for The Hague is Rond de Energiecentrale. It has a transport-poverty score of three and can be characterised by a high share of low-income population as well as low public transport accessibility. This is paired with a large number of shared cars. In fact, it is the transport-poor neighbourhood with the second-largest positive residual in the data set. Rond de Energiecentrale is centred around a power station close to the city centre and has recently seen a large-scale redesign to create more residential space in the former industrial area (Energiekwartier, 2022). The type of housing in this neighbourhood is very diverse, covering all price ranges and built mainly in the 19th and early 20th centuries as well as in more recent years, especially since 2010 (Klimaateffectatlas, 2021; Energiekwartier, 2022). 25% of the apartments in the neighbourhood are owned by housing corporations and the average income is EUR 27,000 (AlleCijfers, 2022d).

The neighbourhood of Heesterbuurt also has a transport-poverty score of three with a high share of low-income inhabitants and low public transport accessibility. The neighbourhood, which is again situated closer to the city centre has a small number of shared cars that exceeds model predictions. The neighbourhood sees a mix of different income categories, with 46% of apartments privately owned and 26% owned by housing corporations. Almost all buildings in Heesterbuurt were built in the early 20th century up until 1950 (AlleCijfers, 2022f), with the most common building type being urban residential blocks (Klimaateffectatlas, 2021). The average income is EUR 25,400 (AlleCijfers, 2022f).

Lastly, another neighbourhood to analyse is Venen, Oorden en Raden. This neighbourhood also has a transport-poverty score of three and is characterised by a high share of low-income population and low public transport connectivity. However, in contrast to Rond de Energiecentrale this neighbourhood, which is situated in the south-western periphery of The Hague sees no carsharing supply at all. The largest portion of the housing in this neighbourhood is found in high-rise buildings (Klimaateffectatlas, 2021) and 54% of apartments are owned by housing corporations (AlleCijfers, 2022e). The majority of buildings were built in the 1950s and 1960s and the average income is EUR 17,900 (AlleCijfers, 2022e).

Enschede

Enschede is selected to represent the municipalities that are currently performing more poorly when it comes to carsharing supply. The municipality has few neighbourhoods where shared cars are available and no more than 2 shared cars can be found in any one neighbourhood (figure 10). This aligns with the fact that Enschede was also one of the lowest-performing municipalities in the municipality dummy analysis putting it in the 24th spot of 30 municipalities in the dataset. Enschede also does not have any neighbourhoods with large positive residuals. However, one of its' transport-poor neighbourhoods appears in table 7 as it is one of the largest negative outliers in the dataset, indicating that it performs substantially below model predictions when it comes to the number of carsharing vehicles available. As this neighbourhood is the site of a university campus it however falls out of the scope of this research and will therefore not be further considered.

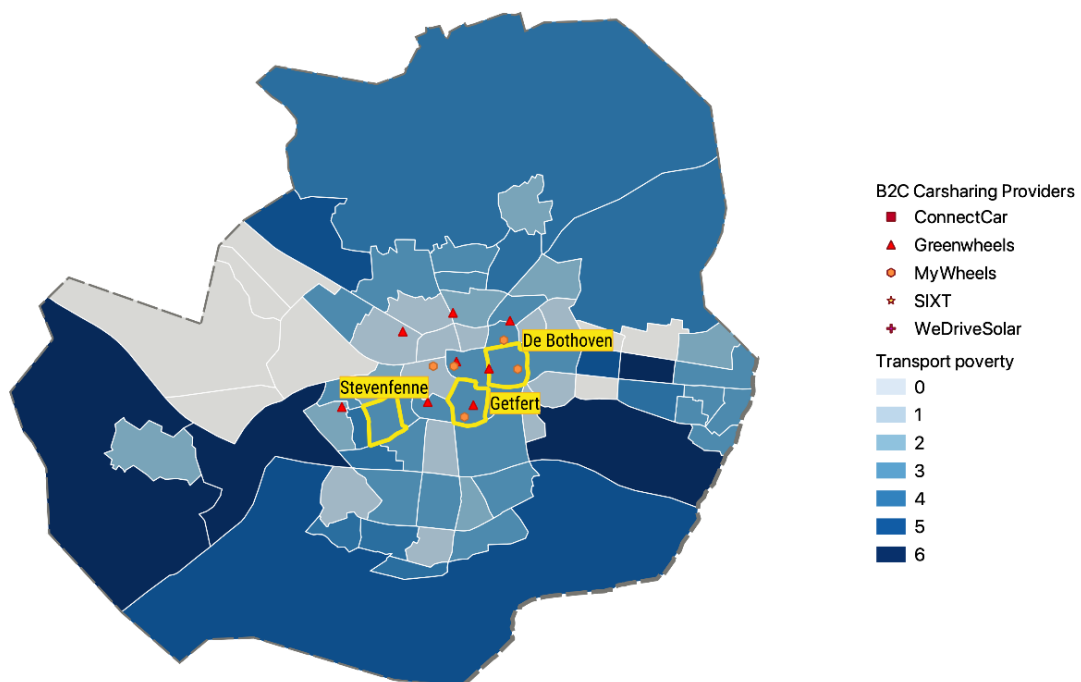


Figure 10: Transport poverty, locations of shared cars and sample neighbourhoods in Enschede

The first neighbourhood in the Enschede sample is one of the neighbourhoods which performs best when it comes to carsharing in Enschede. The relatively central neighbourhood of Getfert has a transport-poverty score of three, with conditions such as a large share of the population with a low income and low public transport accessibility. While Getfert only has two shared vehicles, this is still outstanding in a city with an overall very low carsharing supply, which is also shown by the positive residual of the neighbourhood. Getfert has a lot of housing in the “volkswijk”-style, characterised by small, adjacent houses (Klimaat-effectatlas, 2021). Getfert has seen intensive development in different periods starting in the early 20th century and intensifying again in the 1990s. 38% of housing in Getfert is owned by housing corporations and the average income is EUR 23,500 (AlleCijfers, 2022g).

The second neighbourhood in the sample is De Bothoven. Similar to Getfert, it also has a transport-poverty score of three, with a high share of the population disposing of a low income and low public transport accessibility. It also has a small number of shared cars. Situated just east of the city centre De Bothoven is the neighbourhood with the highest population density in Enschede. The housing styles in this neighbourhood are very diverse, varying between high-rise buildings, cauliflower

neighbourhoods and small, “volkswijk”-style houses (Klimaateffectatlas, 2021). A large part of the real estate in De Bothoven was built or renovated in the 1980s and 47% of apartments are owned by housing corporations. The average income is EUR 22,200 (AlleCijfers, 2022h).

Lastly, the neighbourhood of Stevenfenne is also targeted. Stevenfenne is situated towards the Western periphery of the city and although it is one of the neighbourhoods within the city which has the highest predicted likelihood for shared cars, it does not see any carsharing supply. Stevenfenne, same as Getfert and De Bothoven, is a neighbourhood with a transport-poverty score of 3, a high share of low-income population and low public transport accessibility. The neighbourhood is made up of a lot of “volkswijk”-style houses (Klimaateffectatlas, 2021). Housing in Stevenfenne was predominantly built between the years 1925 and 1970 and 49% of it is owned by housing corporations EUR 19,200 (AlleCijfers, 2022i).

For each of the three municipalities, separate interviews are organised, that focus primarily on the beforementioned neighbourhoods. The interviews are structured in three rounds with interviewees representing different stakeholders of carsharing in transport-poor neighbourhoods: carsharing providers, municipalities, and social housing associations. Table 8 shows in more detail how the interview process is structured. In the first round, the municipalities are targeted. Interviews are done with municipality representatives who are either working in roles focused on mobility or social welfare. As the representatives interviewed in this round, as well as in round three, possess valuable knowledge especially about their local context, these interviews are conducted separately for each municipality with local representatives. In the second round, two interviews are conducted with the directors of different Dutch carsharing providers active in at least some of the sample municipalities. These interviews target all municipalities in the sample, which the providers are currently active in. In the third round, three interviews are held with representatives of social housing associations that are active within the respective municipalities and provide housing in some of the sample neighbourhoods.

| | Interviewee category | Municipality | Details |
|----------------|-----------------------------|------------------------------|---|
| Round 1 | Municipality | Utrecht | Project leader sustainable mobility |
| | Municipality | The Hague | Policy officer smart mobility |
| | Municipality | The Hague | Policy advisor smart mobility |
| | Municipality | Enschede | Policy advisor mobility behaviour and transport poverty |
| Round 2 | Carsharing provider | Utrecht, The Hague, Enschede | Director GreenWheels |
| | Carsharing provider | Utrecht | Director WeDriveSolar |
| Round 3 | Social housing association | Utrecht | Real estate quality consultant Mitros |
| | Social housing association | The Hague | Program manager renewal Staedion |
| | Social housing association | Enschede | Team leader front office Domijn |

Table 8: Interview structure

Potential interview participants are identified through desk research, discussions with the internship organisation Advier and using the snowball effect, where one interviewee introduces another potential interviewee whom he thinks could add interesting insights to the study. The latter means the scheduling of additional interviews, such as for the municipality of The Hague where interviews are done with two municipality representatives, to cover both a more mobility-related and social-welfare-related perspective. This leads to a total number of nine interviews of which seven are municipality-specific and two are taking a broader perspective. The interviewees are invited via email or phone calls to join a one-hour video call with the researcher within a timeframe of three weeks during the research period. An interview guide is created which is adjusted for each interviewee category (see Appendix E).

As shown in Table 9 there are five topics to be addressed in the interviews. The current local performance seeks to confirm the earlier analysis of carsharing supply in each neighbourhood, but also compare it with the subjective perception of the stakeholders and identify explanations. The opportunities for carsharing, analyses the mobility practices present in the local neighbourhood context, especially with regard to the transport-poor population, to understand how carsharing can benefit them. The barriers for carsharing look at reasons for why carsharing is not readily adopted in transport-poor neighbourhoods and the adaptations stakeholders could implement to create an offer that considers the identified opportunities and barriers. Policy intervention looks at how policymakers can become active to support the viability of carsharing as a mobility solution for transport-poor neighbourhoods. In addition to these topics, the analysis also seeks to identify common themes emerging from the interviews that go beyond the pre-defined areas of interest. Based on this approach, the topic of stakeholder responsibility is added during the interview process, responding to a theme that is commonly mentioned in the interviews and deemed to be highly relevant for this research. This topic looks for answers as to which actors should be the driving forces for supporting carsharing in transport-poor neighbourhoods and seeks to understand whether there is agreement on this between the stakeholders. Also, the topics of barriers and adaptations, which were first treated separately, are merged and coded together as they are found to mostly be discussed together in the interviews.

| Interviewee category | Current local performance of carsharing | Opportunities for carsharing/ context-specific needs | Barriers for carsharing and corresponding adaptations | Policy intervention | Responsibility of stakeholders |
|-----------------------------|--|---|---|--|---------------------------------------|
| Carsharing providers | X | X | X | X | X |
| Municipalities | X | X | X | X | X |
| Social housing associations | X | X | X | X | X |
| Coding approach | Open: Municipalities; Satisfactory or inadequate | Deductive: 3 elements of practice: materials, competences, meanings | Deductive: Availability + 5 attributes of innovation: observability, compatibility, complexity, relative advantage, trialability | Open: Types of policy: regulatory, restrictive, and facilitating | Open: 3 interviewee categories |

Table 9: List of interviewees, interview topics and coding approach

While the interview guide provides concrete questions to investigate these topics, the interviews are conducted in a semi-structured way leaving room for the interviewer to adapt to the specific experiences and knowledge of the interviewee. Finally, the interviews are analysed in NVivo (QSR International Pty Ltd., 2020) using a coding approach which is partially open and partially deductive, as illustrated in Table 9. The deductive codes are derived from the literature introduced earlier, such as the elements of a practice (Shove et al., 2012) and the attributes of an innovation (Rogers, 2003). They are therefore based on established theories which provide a helpful framework for analysing the interview results. Additionally, the open codes are assigned by the researcher based on the analysis of the results gathered throughout the interview process and are used mainly to structure the codes. Following an iterative approach, with multiple rounds of interviews between which the interview guides are re-evaluated allows for the integration of additional findings along the way. Interviews can provide the most suitable data for analysing practices, as interviewees can give form-free answers, leading them to speak about actions they otherwise take for granted (Hitchings, 2012). Interviewing individuals with different backgrounds allows for the combination of knowledge to conceive of founded strategies for using carsharing to mitigate transport poverty. This includes insights about current barriers and how to overcome them in order to expand the market coverage of B2C carsharing to transport-poor neighbourhoods. Importance is placed equally on considerations of economic feasibility and social impact potential. Lastly, the analysis aims to also understand whether there is a consensus between individual interviewees and interviewee categories or whether there are points of disagreement. The participants of the study are offered to be provided with a final draft version of the report to confirm whether their statements are interpreted correctly and to decide whether they would like to be anonymised. Based on this feedback, some minor corrections are made to the original results. All interviewees agree to the publication.

5.2. Results

The results presented on the following pages are structured in five sections corresponding to the topics stated in Table 9.

Current local performance

The current local performance of carsharing in transport-poor neighbourhoods is described by all interviewees to be low, especially when compared to the central areas of cities. The municipality representatives agree that providers are targeting especially those areas with a high population density. The municipality interviewees for The Hague additionally state that the higher parking pressure and lower car ownership rate in the city centre are factors attracting carsharing providers. The providers describe that they are not specifically looking to only target the city centre, but rather supply their cars “anywhere where it makes sense” (GreenWheels). This is explained by their common goal of “taking cars off the street”, which means that they are theoretically interested to supply shared cars anywhere where they will be used frequently and where they will lead people that currently drive private cars to give up on these. Their assumption is that car ownership in transport-poor neighbourhoods is much lower than in the city centre. In addition, the director of WeDriveSolar explains that the majority of their users have above-average education and they find the “interest outside [their] main group to be very low, even when making [their offer] very attractive”. He remarks about addressing transport-poor neighbourhoods: “If we look at growth in multiple areas in cities we are now active in, then [...] the uptake while being there is much lower”. He also says that even providers with many years of experience do not have many cars in transport-poor neighbourhoods, which he interprets as a sign that there is not much demand. To decide what areas to target next, Greenwheels applies a data model, which it says has in recent years also led to them expanding to smaller municipalities.

The interviewees for the municipality of The Hague state that they are not currently engaged in any collaborations with providers or employing any specific policy to target the transport-poor neighbourhoods. The social housing associations Mitros and Staedion indicate that while they are now cooperating with carsharing providers, they are currently only starting by implementing carsharing in their new developments, meaning that it is rolled out at a slow rate, for example still not reaching any of the sample neighbourhoods for the housing of Mitros in Utrecht. It is also remarked by the representatives of all municipalities that overall carsharing rates are still very low across all their municipalities considering local car ownership rates. In Utrecht, the frontrunner of the previous quantitative sample, the representative says: "We have around 1,100 B2C shared cars [...] and 120,000 private cars [but] to have a real impact we need about 20,000". It is however assumed, that they "will probably reach that goal in around seven or eight years". Enschede is still far behind the other sample municipalities, which is also remarked on by the representative for the social housing association Domijn: "there's a number of carsharing services here, [but] not as much as in Utrecht or in other cities in the West". The municipality representative for Enschede however says that "if you look at the commercial car sharing parties then we have a large increase in the last couple of years".

Looking at the sample neighbourhoods, in Enschede it is remarked by the municipality representative that "especially for those [sample] neighbourhoods [...] car usage is really high". He also says that De Bothoven and Getfert outperforming Stevenfenne in terms of carsharing numbers can be attributed to the fact that "they are close to the city centre". While the parking pressure in Getfert and Stevenfenne is already high, because of the old buildings there offering "relatively little space for cars", it is said that De Bothoven is "crowded with cars" and that the yearly analysis of available parking spots has shown that the neighbourhood is "one of the areas in Enschede with the highest usage of parking spots". This, however, can be attributed not only to the residents themselves but also to people going to the city centre and parking their cars there. While De Bothoven has a train station within walking distance, the remaining two neighbourhoods only have bus connections. According to the representative, the municipality is currently working on a carsharing policy, and they also have plans to place 23 neighbourhood mobility hubs around the city. This will first target the neighbourhoods further away from the city centre, including a hub next to a shopping centre in Stevenfenne and eventually come to include hubs in all sample neighbourhoods.

For The Hague, the representative of Staedion, explains that the neighbourhood of Venen, Oorden en Raden belongs to the district of Escamp in the south-west of The Hague which is quite car-based and is "known for a very poor social situation, so the amount of social housing is really high and probably by lack of other investments, the neighbourhood went [...] down. So, the level of the income is low, health conditions are low. [There are poor] job opportunities". Additionally, it takes longer to get to most places from this part of the city: the city centre, Westland where a lot of the work is, and the sea are all hard to reach. The representative of the municipality talks about the issue that "in the neighbourhoods built before the war, there's not a lot of space. So, we need to make space and the fastest way to make space is to basically stimulate people to get rid of their car to create space in the streets". In Rond de Energiecentrale, a project has been done to include carsharing as part of an innovative development project focusing on the Energiekwartier, which it is a part of. It is said by one provider that The Hague is doing well in terms of taking "the lead [...] in informing their inhabitants about the positive effects and advantages of using car sharing".

Lastly, in Utrecht the representative of Mitros estimates that especially in the neighbourhoods of Transwijk-Zuid and Lunetten-Zuid transport should be fairly easy with good bike infrastructure, and a train station close by. The municipality representative however adds that while Lunetten is

accessible by train, there are not many other public transport options to connect the local area. About Transwijk-Zuid he says that it is “weird because the bus transport is so dense in that area, but still people find it hard in some way and necessary to buy a lot of cars”. He remarks that in Transwijk-Zuid, and most likely also the other neighbourhoods, car ownership is very high, and you can frequently see “three, four, five cars in a household”. Transwijk-Zuid will however see the introduction of paid parking permits starting on the first of July, aiming at reducing car ownership in a program which was introduced first in the city centre, and which is now increasingly expanded to include more neighbourhoods. He also says that currently thousands of houses [in the city] are being built with less than the standard car parks and more than the standard shared cars”. Lastly, he adds that a new mobility hub will be opened next to Transwijk-Zuid in September that “is definitely focused on people with low access to mobility or mobility poor areas”. Zuilen-Noord is described by both the social housing and municipality representatives as an area where public transport is more difficult. It is therefore suggested by the social housing representative that this might be an area where carsharing could be a good solution due to the lack of other options. It is described by the municipality representative that in Zuilen “there's a lot of things going on”, referring to a new carsharing hub with 25 cars. However, policy-wise there has not been any commitment thus far to improving carsharing specifically in transport-poor neighbourhoods.

Mobility practices and opportunities for carsharing

Many of the interviewees admit to not being familiar with the mobility practices and needs of people experiencing transport poverty. The director of GreenWheels for example mentions that they do not profile their users on income and therefore do not have any concrete experiences when it comes to this specific group. A representative for the municipality of The Hague also adds that they do not have a good look at how people experiencing transport-poverty travel now and want to travel. And a representative of Mitros says that they do not know whether mobility makes a large share of their residents' income.

Regarding materials, it becomes obvious from the interviews that there is some inconsistency between the expectations and experiences of stakeholders regarding whether many of the households in transport-poor neighbourhoods own cars. The representative of The Hague for example says that “people with lower incomes are less likely to own a car”. This also is in line with the expectations voiced by the director of WeDriveSolar, saying that “car ownership in low-income areas is already very low” and that therefore a lot of the residents are using public transportation as they cannot afford cars. Other stakeholders contradict this, such as the representative of Staedion who says that many places that people would travel to for work or leisure are hard to access by public transport and that people can be dependent on their car for their commute to work, so car ownership is actually high. The representative of Utrecht adds that people in these neighbourhoods often use old cars as many start work early in the morning when public transport is not running yet. He estimates that people spend around EUR 300 a month or 20 to 30% of their income on a private car. The director of WeDriveSolar puts this estimate even higher, saying it could be around EUR 400 to EUR 500 a month. The director of Greenwheels also adds that it is becoming increasingly difficult to own a car due the introduction of parking permits, the lack of parking spaces and the rising petrol price. This notion is shared by the representative of the social housing association Domijn who says that the war in Ukraine and the resulting energy crisis are factors that could make it “completely impossible to drive” for “3,000 [of their customers] roughly estimated who have to live off 50 or 70 Euro a week, sometimes with kids”.

In contrast to assumptions of low car ownership among people in transport-poor neighbourhoods also stands the observation by multiple interviewees that free parking spaces are hard to find in

these neighbourhoods. As the representative of Domijn says: “We have too many cars”. He recounts that in their meetings with tenant representatives “parking is always one of the main themes. There is always too little parking space, and it’s subject to a lot of discussion”. Additionally, it is mentioned that residents employ a variety of transport modes, such as public transportation and biking, but also “a lot of walking” as the representative of The Hague says. The availability of public transport varies between the neighbourhoods but is often described to be rather scarce, with sometimes only a “train, but then nothing”, like in Zuilen-Noord or no train and only bus connections, like in Getfert and Stevenfenne. In Utrecht, the municipality has recently also started to supply these neighbourhoods with shared mopeds and bikes. An app called Gaiyo helps residents to view all the shared mobility options in their neighbourhood. Generally, most of the interviewees agree that most residents dispose of smartphones to be able to access these applications.

Looking at the competences of residents, a commonly mentioned issue is the lack of financial literacy. It was described that households often did not have a good understanding of the costs they incurred due to car ownership. As the director of WeDriveSolar described it: “there is a huge misconception on how much a car actually costs”. According to him, as many people buy second-hand cars, they incur higher repair costs. But as these costs are not calculated on a monthly basis, people do not relate to what they are spending, reducing their urgency in identifying alternatives. On the other hand, the knowledge of how to use smartphones and the internet is becoming less of a barrier, as the director of Greenwheels says. Language however can be an issue, according to the representative of Staedion. As people speak various languages, Dutch and English are often not enough to communicate with residents. Another potential issue that is contested among participants of this study is the possession of a driver’s licence. While the representative of the municipality of Enschede thinks that most low-income inhabitants do have a driver’s licence, the representative of Staedion questions this. Additionally, especially in low-income groups, young people are often finishing school and starting work around 16 years old, which means that they will not be legally allowed to drive a car yet.

Finally, looking at the meanings held by transport-poor households, the representative of the municipality of Utrecht says that “you have three or four generations living in a social housing project and the people are more or less stuck, because especially the young people [...] still have to live with their parents and grandparents”. In addition, the representative of The Hague remarks that “people with a very low income who are experiencing transportation poverty can get quite isolated from society. These people might, for example, only visit their local supermarket and some neighbours or relatives who live nearby”. In line with this, the representative of Staedion says, that some tenants do not have a lot of contact with other people and therefore hearing about innovations or new offers can be more difficult for them. She adds that they often have lower trust in institutions, so they need to be reached through their existing channels, such as at work or school and talked to by people they trust.

Multiple reasons can be identified for why households are valuing car ownership. These can often be work-related: people have jobs in facilities such as hospitals and distribution centres, where they work shifts. This leads to them commuting at inconvenient times, such as early in the day when public transport is not running yet. It also means that being late is less acceptable for them than for someone working in an office, as the representative of Staedion describes, leading to them preferring the car over complicated journeys on public transport that can be less predictable. The representative for Domijn also states that cars are important for low-income residents in Enschede as they might often have to travel further to get to their workplace than people in the West of the country, with public transport being inadequate. He also states his doubt whether “people who

really have to use cars for work will really have the guts to depend on that there's a sharing service that will provide them with the car every day", saying that carsharing will be better suited for recreative purposes. Another reason for sticking with car ownership and accepting the high cost is that it is simply a habit to most people. As the representative of Domijn recounts: "When I went to study in Utrecht it was quite normal not to have a car. It's different here. There are less people who go to higher educations like a university. And here it's more normal to actually have a car when you're 18. It's a logical step". The representative of The Hague however believes that this will play less of a role for the younger generations, as they "tend to be more open to trying new things". Other mentioned reasons for valuing car ownership include having a means of transport for visiting purposes, so they can reach places that are not easily accessible by public transport, but also clinging to the reassurance of having your car parked in front of your house in case you need it, as the representative of Mitros says. The representative of The Hague adds that it is also hard for people to give away their car because it feels like "giving away their freedom" so "especially people with a high car dependence and low income will do anything before giving up their car, for example, share the costs with other family members".

Lastly, it was mentioned by many of the participants that status might play a role. The director of WeDriveSolar states that introducing people to the idea of carsharing is hard because they will say: "if I want to drive a car, I want to have my own and it's completely different from the car you are offering me". In his experience, status becomes especially important for people with a low income. So, when households have enough money to rent or buy a car, they will aim for a car that will enhance their status, which is something most shared vehicles do not do. The representative of Utrecht agrees that people want to be seen in the nicer carsharing vehicles and that if Teslas are used the service becomes much more interesting but also less accessible for low-income households. The representative of Mitros weighs in that people with a low income might value the extra status granted by owning a car, but if they cannot afford it could still regard carsharing as a good option. He says that this might also depend on different perceptions of status and cannot be easily generalised. As people might have reservations about carsharing at first, the representative of The Hague adds that people could be encouraged to try carsharing if it is packaged as a way to try an electric vehicle, something they might be curious to experience. She also adds that introducing carsharing in housing complexes might make it more acceptable, as households would be sharing with their neighbours, invoking a feeling of familiarity. However, it is questioned by the director of WeDriveSolar if carsharing is even needed in these neighbourhoods, as "most people in these areas can do most of the things they want to do within the city area".

Barriers and adaptations

All barriers encountered in the interviews fit within the framework of barriers to adoption as identified by Rogers, with the addition of one barrier representing availability. All six of these barriers are mentioned in at least two of the interviews. The barriers are in the following combined with ideas for carsharing adaptations to mitigate them.

Availability

The lack of availability is often mentioned as the primary barrier for residents in transport-poor neighbourhoods to adopt carsharing. This is intuitive because, as the representative of Enschede says: "If there is no car in the neighbourhood, you cannot use it". He adds that carsharing providers are currently deciding on the neighbourhoods they serve based on various factors such as population density and "the characteristics of the people living in the area", leading to them primarily supplying other neighbourhoods. This is also a shared experience of the representative of

Utrecht who says that there, carsharing providers are also less interested in transport-poor neighbourhoods, as they are associating higher income of the residents with more potential profit. According to some interviewees, this barrier might however dissolve on its own due to the continuous expansion of the market. The representative for Enschede confirms this idea by saying that one can see the providers are now “getting a bit further from the city centre [likely meaning] it’s just a question of time until cars are around the whole city”. This coincides with the director of GreenWheels saying that based on the data model they are applying to decide what neighbourhoods to serve, they are now “also targeting areas that were at least less obvious”, having good experiences in these places as worse conditions for car ownership and better propositions for carsharing providers are “causing people to notice the positive effect of carsharing”. The representative for Utrecht says that the city has “grown [by] about a third of the people, but the size of the city stays the same. Naturally, it’s more dense, and when it’s more dense [...] it’s easier for shared car operators”. Additionally, the director of WeDriveSolar explains that at the moment the electric vehicles they are using are still expensive, but that “maybe in the future it could become profitable” to also serve these neighbourhoods.

Two strategies mentioned which are already starting to be applied throughout the sample municipalities to increase the availability in some transport-poor neighbourhoods are mobility hubs and the addition of carsharing vehicles to carparks in social housing developments. Hubs are mentioned as a possible solution by many interviewees. For example, the representative of Enschede, where the municipality is planning to place mobility hubs with shared cars in central locations next to the shopping centres in each neighbourhood to increase accessibility but also visibility of the service. He also remarks that with these hubs it will become much easier for the municipality to influence where new carsharing supply should be located, as he says: “Instead of companies approaching us for the places where they want to place, we approach the car sharers saying we want to place a hub over here are you interested in placing a car over there?”. The director of Greenwheels however says that he struggles to see the benefit of placing shared cars in hubs as he expects that users would have to walk further to reach the shared cars. The representative of The Hague shares this concern as she says: “I think it makes it easier to locate, but for people who are at distance from a hub it might be more of an obstruction”. Further, adding carsharing to carparks of social housing complexes is perceived as promising by the representative of Mitros as it means “introducing [it] into the physical environment of some tenants [which] might be a trigger [for them] to actually start using it”. The director of GreenWheels adds that introducing policies to support this development provides “exactly that push effect that [he thinks] municipalities or governments can play more of”. While this measure is said to be commonly applied in new housing developments in both Utrecht and The Hague, the representative of Domijn says that he has not heard of it being done in social housing developments in Enschede.

Lastly, the director of WeDriveSolar however, says that he does not believe that availability alone will mean that people will start using carsharing. He reports that they “see in projects when it’s right in your face and it’s available then people of course will start using it more. But if we look at growth in multiple areas in cities [...] then the growth [...] specifically in these areas [...] is really much lower”. The representative for Utrecht adds that “you have to do a lot of communication and spend marketing money. And then you have a low usage of the car [...] but if you put them in the inner city they are booked today”.

Compatibility

There are therefore clearly more barriers at play, one of them being compatibility. There are multiple examples for a lack of compatibility between the need for mobility and the current

proposition of carsharing providers. One big factor seems to be the payment. This can be a barrier for those people “who don’t have a credit card” or cannot afford to make a large deposit payment. The representative for Utrecht adds that “a lot of the car sharing schemes [...] use a subscription model. And a lot of people can’t have a subscription to anything that costs money due to all sorts of credit systems”. The representative for The Hague also mentions that carsharing cannot be a good mobility option for everyone, as for example wheel-chair users cannot ride shared vehicles. He comments on the importance of being inclusive when deriving mobility solutions and underlines the continued importance of public transport. Further, many interviewees mention language barriers when trying to use the app, for those people who do not speak Dutch, English or German. And lastly, it is mentioned that access to the mobile app could also be a barrier when thinking about “elderly people who maybe have smartphones but don’t really know how to use apps”. Addressing the consistency of carsharing with the values of people in transport-poor neighbourhoods, according to the director of WeDriveSolar, people often feel that if they want to drive a car, they want to have their own and that for them it is completely different to using a shared vehicle. This connects also with the importance of status discussed previously.

As potential solutions, the interviewees offer the following ideas. The director of GreenWheels explains that in response to the payment issues they are piloting a lower deposit, down from EUR 225 to EUR 50 to make the subscription more affordable. He says that it also could be part of a launching campaign, that the municipality pays the deposit for new carsharing users with a low income. The representative for Utrecht also mentions the following concerning a current pilot scheme in the municipality: “What we’re focusing on for the pilot is to take away [...] their own risk when [they] have an accident but also [to] try to open up subscription. So maybe they have the city sign the subscription and pay the subscription”. According to a representative of The Hague, another benefit of running pilots can be to investigate the needs of the residents, such as whether “people need more shared cars instead of shared bicycles or the other way around”. These results can then be extrapolated to other neighbourhoods that are alike, increasing the compatibility of measures with local needs. Further, the representative of Utrecht mentions a concierge service that could be offered at mobility hubs, as another feature they will try in their pilot. In theory, this could help people who struggle to use the mobile application or people with language issues to get familiar with carsharing and learn how to open the vehicles using the alternative keys. The director of GreenWheels also says that they still provide a card reader as a way to open the car without a phone, for those people who are not comfortable with using apps, but remarks at the same time that a concierge service is “very, very expensive and most of the people are online the whole day, so it is a bit of a traditional, old-fashioned way of looking at it”.

Regarding carsharing providing users with a different feeling to driving their own car, one approach to improving this could be to decrease the marketing on the outside of shared cars. The director of WeDriveSolar says: “In our offering we only have a very small logo, and we are using neutral cars like white and grey [...] and our clients, they really give us feedback on that [and] say that they really appreciate the fact that they are not driving in an advertised car”. Another way to enhance the perception of status for carsharing users is to include more Tesla vehicles. The director of WeDriveSolar says that Tesla is “a brand associated with luxury, a modern, trendy car that they want to be associated with” and recounts that when offering these cars in lower-income neighbourhoods the provider started to receive a lot more interest, because “if you don’t have that much money and you’re spending money on mobility, on a car, then you will spend it in such a way that it will lift up your social status”. He also says however that this will not be an appropriate solution in the long-term because Teslas are the most expensive car in the providers’ range, so “you don’t solve it, you enhance the problem”.

Complexity

The director of GreenWheels says that carsharing “remains a complex service” and that generally people have a lot of questions about how it works. A representative for The Hague says that “the thing [...] with car sharing or with shared mobility as a whole is that a lot of people are not familiar with car sharing and they also don't know how it works” and that “people with lower income might be more hesitant to use a shared car because it's [...] a brand-new car or it's an electric car and they might not be used to driving those, or might be afraid for possible damage costs”. The representative of Mitros adds that not knowing the conditions can also scare people as they are not sure whether they need to put “it back in the same space or within the same car parking space”. The digital application is mentioned as a barrier as well, as “there's the expectation that people are able to do everything with an app. And I think it goes for a large share of our population, but also a large share of our tenants [that they cannot] really work it out, understand the conditions [and] have the right perception” and it can also be a challenge especially for “elderly people who maybe have smartphones but don't really know how to use apps”. A related problem identified by a representative of The Hague is that currently “if you walk past a GreenWheels car you only have a board that says ‘autodelen’ and there's no more information. So, if people walk by and they want to know how it works, they are not informed directly [but] that's crucial”.

The representative of The Hague thinks that one approach to dealing with these issues could be for the provider to supply more staff which could spend some “hours to educate people on how to use apps, how to use an electric car”. The representative for Mitros appreciates that WeDriveSolar is providing such a service to their tenants explaining to them “how to deal with this kind of mobility”. He also says that “in the future [...] that might be part of the contract we want to have directly with those providers. [So that] next to providing it [they are] also making sure that an explanation of how it works and how easy it is to use is provided”. Additionally, it was mentioned by a representative for The Hague that it is important that the providers adjust their proposition to make the service “as easy and accessible as possible [...]. And that goes for actually using the car and finding the car but also using the app and the payment methods”. The director of GreenWheels agrees, saying that they are already looking into adapting their proposition to make it simpler for the users. Lastly, marketing campaigns are mentioned as an important tool to educate people on how to use carsharing. The director of GreenWheels says that Amsterdam and The Hague were now taking a good approach, organising “certain days when you can sign up or talk to someone” about the service. In Amsterdam, for example, multiple times a year “they organize an area [...] where a few providers have a car standing there and a colleague standing next to the car [...] to answer any questions of people dropping by”. The representative of The Hague says that it can also be a good idea to go directly into those neighbourhoods and ask people on the street whether they “want to know how this works and [...] want to try it”. Lastly, there is also a plan to start providing more information at the mobility hubs by using panels providing “information about what shared mobility is”.

Observability

The next barrier, the observability is, of course, related to the availability. As the representative of Domijn says: “when it's offered you start to think about it. So there has to be some beginning for people to take up on it”. The representatives of The Hague and Utrecht describe that in the city centre you see many shared cars but when you are in the sample neighbourhoods you cannot see it very often, therefore not creating much awareness among the locals. But the representative of Mitros says that even when the vehicles are there, still more might have to be done to increase awareness, so people know “that it's there [and] that usually it's just right around the corner from where you live”. This awareness is currently described by the representative of Staedion to be low as

for inhabitants of social housing carsharing is “really not a world that’s known with a lot of them. [Some] don’t watch national television” and “you hear from a lot of people that they actually don’t meet other people. So how do you know [about it] then if you just do what you did yesterday”. Lastly, the representative of Mitros describes a key moment when observability of carsharing is important: “At a certain point either your car breaks down and you think [...] how should I solve this, that’s [...] a key moment to make a transition towards something [like shared mobility] but that option should be on your mind”.

In terms of solutions, that marketing is important. On the one hand, the interviewees mention that in these neighbourhoods “you have to do a lot of communication” and “big public campaigns about using shared cars”. On the other hand, the representative of Staedion says that it is also important to go into the neighbourhoods personally to “talk with residents and explain it”. This opinion is shared by the representative of The Hague who also suggests to “meet people on the street” to talk to them. But it is also mentioned by the representative of Staedion, that it would be good to find further channels to communicate through. As “the trust in institutions is not that high in these areas, it’s really important that they talk with people who they trust [...], maybe via school, via work, [...] using the relations they already have”. Another solution that was mentioned, that could help with observability issues, are again the mobility hubs. The representative of Enschede mentions that once they will have more hub locations within Enschede “people get familiar with carsharing [and] know there are shared cars in Enschede, so maybe they are going to look it up once, maybe try it once”.

Relative Advantage

One of the most-mentioned barriers is the lack of relative advantage of carsharing over other mobility practices. This barrier considers on the one hand the actual disadvantages of carsharing in certain usage scenarios, but on the other hand also the wrong perceptions leading people to not see the advantage of carsharing. About the real disadvantage, it is mentioned that shared cars are not an interesting option for users who rely on their private cars for their daily commute. The reasons for this are that people are hesitant to depend on the availability of the service but also the financial disadvantage compared with driving a private car when using carsharing daily. The representative of Utrecht explains that “if you have to go to work five, six, seven times a week at 6:00 o'clock in the morning and you have to park your car for nine hours at your workplace and then drive back again. If that’s the case [...] shared cars are much, much more expensive”. This is also acknowledged by the providers, with Greenwheels saying that carsharing is cheaper than buying a car for people who do not “drive more than 10 to 15,000 kilometres a year [...] but it still remains expensive [because] petrol is expensive, a car is expensive” and that therefore for low-income users their service will be much more useful for incidental trips. Talking about wrong perceptions acting as barriers, it is often mentioned that people have a false idea of the real cost of car ownership, which the representative of Staedion says people are “really underestimating”. According to the director of WeDriveSolar, carsharing could lower the mobility costs of a lot of people but they “under-estimate the cost of owning a car. So, they buy a second-hand car, and they pay the price and then they forget how much they paid for it. And then on the second-hand car, the repair costs are higher, but it is not calculated in a monthly way, so [...] there’s a huge misconception on how much a car actually costs”. The representative of Mitros agrees that there can be an issue with the perception of the cost as “being confronted with a relatively high price for just a short drive might also be a little bit discouraging”.

As a response to the financial disadvantage of carsharing use for the daily commute to work, interviewees underline the importance of offering a transport mix with good public transport and biking infrastructure. As the representative of Utrecht says, it is much more interesting to have more public transport which people can use for their commute and have carsharing “for specific rides

which a lot of people don't need to make on a daily basis [like] when you're moving". This coincides with the director of GreenWheels saying that they always tell people: "Take the bike or public transport first, but if you really can't use that then we're there for you". However, with more people using carsharing in the future, the cost of the service could also go down, making it more accessible, according to the representative of The Hague. Lastly, the representative of Enschede mentions a different approach to increasing the affordability of carsharing: "At this moment we subsidize public transport and maybe you can talk about [including] car sharing, shared mopeds, shared bicycles, all those [...] also within the subsidy for public transport".

To combat the wrong perception of the relative cost of carsharing compared to car ownership, the representative of The Hague says that it is important to educate people on how carsharing is more effective and cost-friendly for them. It would be good to explain to people that with carsharing "there are almost no hidden costs" and to remind them that when using shared cars, they do not have to pay insurance, taxes, parking cost or maintenance – variable costs that are often forgotten when thinking about the cost of car ownership. The representative of Staedion also thinks that it is important to explain to their tenants what "the costs are to be mobile in different forms". The director of GreenWheels adds that "if a municipality is really eager on trying to activate a certain area [for carsharing] they have an important role to play there" in terms of using their position as an independent party to inform "their inhabitants about the positive effects and advantages of using carsharing". Another factor which will start adding to the relative advantage of carsharing over time is the parking permit situation. Currently, residents in many of the sample neighbourhoods are not relying on parking permits yet, but the representative of Utrecht notes that the zones will keep expanding. For example, one of the sample neighbourhoods in the municipality will see parking permits "coming from the 1st of July".

Trialability

Lastly, the trialability of carsharing is mentioned as a barrier, mainly because of the need for making the deposit payment before using a shared vehicle. A representative of The Hague says that the deposit is "a barrier because you don't really expect that right away, you're going to use [carsharing] often. [And] it doesn't matter if you get it back afterwards, it's the up-front payment that is the killer here". Many interviewees suggest that vouchers might work to increase the trialability. The representative for The Hague says that they "did this action also together with some commercial companies [where they] had a sort of voucher with 35 Euro and then people could use the shared car for a couple of times. I think the municipality paid 20 Euro for the voucher and commercial companies like 15 Euro". The representative of Staedion and Mitros also think that vouchers could create the initial interest and help people try it out for a month. Also, approaching people in their neighbourhoods and asking them if they would like to try to use it could be a good idea, according to the representative of The Hague. Lastly, the representative of Enschede thinks that the mobility hubs will help by giving people a place to try carsharing.

Policies

Policies are mentioned by many interviewees to be essential for improving the mobility in transport-poor neighbourhoods. The director of GreenWheels explains this by saying that policies "provide the context in which carsharing is adapted or not". At the same time, all municipality representatives say that there are currently no policies active in their municipalities that are focusing specifically on carsharing in transport-poor neighbourhoods. However, many of the policies which are targeting carsharing at a more general level still have a positive effect on transport-poor neighbourhoods. The representative of Enschede says that he believes that the municipality is "still in a phase in which all

the shared mobility is new [and they] try to facilitate it as much as possible, but also regulate it where needed". He says that in the future, if data will suggest that certain neighbourhoods are lagging, it will also be interesting to look at how to stimulate carsharing in these neighbourhoods, but that at this moment there is no data yet and there is not much thought about it. A regulatory policy measure that the municipalities can apply to specifically increase carsharing in transport-poor neighbourhoods is the introduction of parking envelopes. As the representative of Utrecht explains, this could mean for the providers that for example "for every five cars in a very profitable area, you have to add the sixth car in the not so profitable area". The director of WeDriveSolar also mentions that this is a possible measure and that they are currently working with the municipality to arrange this. Further, the representative of Domijn says that he "can imagine that in the near future, mobility [...] will be a demand that cities can ask from social housing associations".

A restrictive parking policy which addresses both the demand and supply side of carsharing is regulating parking permits. The director of GreenWheels says that as more players are entering the carsharing market it becomes more important for municipalities to regulate how they use the "precious public space". Currently, most municipality representatives describe that the providers mainly choose the places where they would like to place cars and then apply for a parking permit with the municipality. But the location of shared vehicles could also be influenced by selectively lowering the price of parking permits for shared cars in desirable locations, as is described by the representative of Utrecht who explains how the municipality is rolling out carsharing in all their public car parking garages throughout the city: "A normal parking permit in the garage is around 200 Euro a month and we charge only 50 Euro for those for the carsharing providers so they get a pretty big discount". It is also mentioned by the representative of Enschede that the issue of parking licenses could be improved to facilitate this process. He says: "Nowadays they have to get a parking license for commercial usage, but maybe we can put another parking license [in place] especially for car sharing". Also, with regard to the demand side, parking permits can help to make car ownership less attractive. In Utrecht for example, there is "a policy not to give out parking permits [...] for new inhabitants" in the more central neighbourhoods of the city. He adds that the area where parking permits are necessary is currently expanding in the municipality like a waterbed and that "every half a year the areas where we add zones for parking permits increase and usually people" get the number of parking permits corresponding to the number of cars they have at that moment at around 10 Euros a month, therefore putting a price and eventually a cap on parking and increasing the relative advantage of carsharing usage.

Looking at facilitating policy, one much-discussed policy instrument to help with increasing carsharing supply are parking standards for housing developments. Municipalities like Utrecht and The Hague have introduced the possibility for developers to reduce the number of parking spaces in housing projects by including space for shared cars. According to the representative of The Hague, this is a good incentive for social housing associations because it means that they can turn the saved space "into more houses and more houses will become more profit". He however adds that not all developers are incorporating this concept. According to the representative of Utrecht however, it is used frequently with "thousands of houses [that] are being built with less than the standard car parks and more than the standard shared cars". He also says that increasing the attractiveness of this incentive is another restrictive policy which stipulates that in the development of new housing projects, developers can no longer plan to use public spaces for car parking, therefore putting more pressure on them to make use of the carsharing solution. Another facilitating policy targeting the demand side is the introduction of a carsharing subsidy, where for low-income households a part of the carsharing cost could be taken on by the municipality, making it more affordable. The representative of Enschede mentions that carsharing could be included in the subsidy that is also

granted on public transport and that this could be a way to “decrease the amount of time before you get a really good usage”. Similarly, the municipality could also “sign the subscription” and pay the deposit for low-income users to take away their “own risk when [they have] an accident but also try to open up subscription” as the representative of Utrecht says. The representative of Staedion suggests that the municipality looks at the costs and what you can “expect based on an income what people can spend on mobility” and then design a subsidy to make it affordable. The director of GreenWheels cautions however that once a business case can be achieved in a particular context, he does not “believe in subsidies [...], because that only attracts parties that try to get that subsidy without really thinking about the underlying business model”. He therefore is more in favour of another temporary, facilitating policy addressing the supply side. He explains that “there should also be [a] financial airbag, like a turnover guarantee [which] will make sure that at least the first [...] six months, you break even” when serving areas which are not the providers first choice, such as transport-poor neighbourhoods. The director of WeDriveSolar agrees that this could be a good measure.

Not directly related to carsharing, but also often addressed in the interviews is the need for the municipality to make policy to support the accessibility of public transportation in transport-poor neighbourhoods. The representative of Staedion suggests that people might prefer to travel by car “because it’s so expensive to travel by train” and because the connections in some neighbourhoods are poor. She also mentions a policy introduced in Germany, which allows people to use public transportation for a low price during the summertime. The director of WeDriveSolar goes as far as saying that he thinks that “public transport and bikes are the answers to mobility poverty in cities” and that the municipality should start by investing in increasing public transportation and bike infrastructure in transport-poor neighbourhoods. According to him, it is “way better to subsidize bike usage because it’s much more effective and really has an impact. If you provide a few shared vehicles in a large area [...] it’s really a very small part of the mobility while with the same money you can maybe get 1,000 people on a bike”.

Lastly, the representative of Utrecht says that “there is policy being made to receive standard data protocols [...] every three months from all the providers who want to be active in Utrecht from the first of January 2023 [...] and then it can be shared with [...] different cities”. This will then also help the municipalities to learn from each other and benchmark their carsharing outcomes. It might also help to address a concern of the director of GreenWheels who criticizes that “there’s a very high lack of knowledge at municipalities and I’m seeing very strange decisions made” by policymakers who do not understand the carsharing providers and make policy without argumentation. But he also says that this is not true for all municipalities, as he says about Amsterdam: “For the policy side of things I think they [...] really understand it”.

Responsibility of stakeholders

Providers

Talking about their understanding of the role they could play in addressing the mobility issues of transport-poor residents, it can be said that providers, the municipalities, and the social housing associations see themselves in different positions, with perceptions sometimes even varying between different representatives of the same category. The director of GreenWheels describes their mission in the following way: “To offer an alternative to car ownership and to make that alternative [...] maybe even better than owning a car, [so] that we are able to change the behaviour of people” and “take other cars off the street”. He adds that while they are not yet a car for everyone, they are trying to become that, which for them will also mean serving areas where

mobility is scarce. He however emphasizes that they have to choose their locations carefully because carsharing is a “very marginal business” and they “want to continue what [they are] doing forever and not take too much risk”. He therefore says that placing a car has to make sense for GreenWheels in two ways. First of all, it needs to fit in with their mission of decreasing the number of cars on the street, meaning that the supplied cars need to be used and reduce car ownership as a result. Secondly, supplying the cars in transport-poor neighbourhoods needs to make sense for them financially, meaning that making losses is not an acceptable option as it may jeopardize the company’s overall success. According to him, if the municipalities see carsharing as a good way of addressing transport poverty, they have an important role to play in supporting it in areas where providers will not immediately see a business case. He says that subsidizing carsharing and providing turnover guarantees can be good steps to do so. In his opinion, another powerful approach the municipality can assume is for them to “use their position as an independent party [to inform] their inhabitants about the positive effects and advantages of using car sharing”. This is important as it leads to more effective communication when the message is perceived by the recipient as objective, rather than a purely financially motivated marketing message. He says that Amsterdam and The Hague are both doing this well, by taking the lead and organising information days.

The director of WeDriveSolar explains that their target is slightly different. They also aim to “offer a replacement for car ownership”, however they are most interested in serving users who use the car more frequently than “just once or twice a month”. He explains that WeDriveSolar is “focusing on the people that are spending money on mobility and who have like one, two, three cars [...] because getting these cars out of the city actually has an impact”. He also mentions that he sees limited financial viability for providing shared cars in transport-poor neighbourhoods as using carsharing for the daily commute would be expensive, the trip to the supermarket is commercially not interesting as it is a short trip in the middle of the day, and the long-distance trips to locations inaccessible by public transport would therefore be the only interesting usage scenario left. It is mentioned by the director of GreenWheels that it is important to start by understanding “the root cause” of the issue and understanding whether carsharing can offer a solution. He remarks that he does not have “the knowledge of the social issues in these areas that municipalities see”, but that he thinks that investing in biking and public transport infrastructure is essential. The director of WeDriveSolar even says that he does not think that “shared vehicles are the answer for these neighbourhoods” and that “the best thing you can do, from a government perspective, is to provide bikes, bike culture and bike infrastructure [as] when you give someone a bike their travel radius on an average day immediately expands, happiness grows [and] it's healthy”. He reminds of WeDriveSolar’s mission of reducing car ownership, saying that “car ownership in low-income areas is already very low” and their goal is not to “help people who cannot afford a car to get them in a car [because] it's best that they never drive a car”. This relates to the concern of the director of GreenWheels, whether offering shared cars in transport-poor neighbourhoods can help them to drive their mission of reducing the overall number of cars on the streets.

Concerning the demographics they serve, the opinions are diverging. GreenWheels says that they do not have typical user demographics and that they mostly segment according to frequency of use: “You have a group that uses us sometimes, then you have a group that uses us a few times a month and then you have a group that uses us very often”. WeDriveSolar however remarks that their user base is predominantly made up of “above average educated people”. The director of GreenWheels also explains that in terms of car placement, they are quite open, placing cars wherever they see an opportunity to “take other cars off the street”. They do this either based on requests of people that show that there is enough demand in a particular place or based on their data model predicting demand. Later, when they see certain cars not performing well, they will take them away again. In

the future he says, GreenWheels is open to collaborating with municipalities on further addressing this topic, in a way that multiple mobility providers and the municipality agree on a plan to pilot certain areas within the municipality. WeDriveSolar also mentions that they have been and continue to be involved in multiple pilots together with municipalities and social housing providers.

Municipalities

From a municipality perspective carsharing is seen as a valuable tool to address multiple issues their cities are currently facing, such as the crowded city centres and the lack of parking spaces. As a representative of The Hague says: “the municipality believes in shared mobility and hopes that it will be the new normal [...], so the municipality tries to stimulate this kind of mobility”. Additionally, carsharing is also seen as a promising solution to address the mobility needs of people in transport-poor neighbourhoods so that they can access more opportunities. While all municipality representatives interviewed acknowledge this potential of carsharing, they also make it clear that this is currently not their first priority. One representative of The Hague says that “we are not focusing on specific areas right now [...] because the shared car companies can just ask a permit from us for a specific spot and then the municipality checks if it's okay [...] but of course we try to be inclusive so that everyone can make use of mobility in the Hague. So, there's a little focus for it”.

This approach of letting the providers pick the locations is shared in Enschede, however the representative also adds that they are “thinking about ways to stimulate car sharing more” throughout all neighbourhoods in the municipality. He emphasizes that in Enschede shared mobility is still new and therefore there is not a lot of data yet: “We just need to retrieve data and do analysis [...], and when one of these analyses comes out saying the usage in those neighbourhoods is really low, then we can make certain policy or certain campaigns in those neighbourhoods. But at this moment [...] there's no need”. However, the municipality of Enschede is currently working on a pilot scheme of introducing carsharing in all neighbourhoods by creating mobility hubs, therefore also targeting the transport-poor neighbourhoods as a side effect. Lastly, the representative of Utrecht remarks that while the providers usually scale up “in the areas where they can make more money [the municipality has] some policy steps to help specific niches” and to “help people with lower income in certain neighbourhoods”. But he also remarks that he would “rather have five new cars extra to make the inner-city car free and then they drive around in the city, and it will be marketing of itself [rather] than to have a few weeks of work to have one car in one of those neighbourhoods, [therefore] focusing on scale-up where it's easier at the moment”. Concerning the calls to provide more public transport, the representative of Utrecht says that the municipality is “looking at the need to increase public transport as well, so shared cars are just one of the [targets] and definitely not the biggest”.

The opinions diverge among the municipality representatives when it comes to financing. The representative for Utrecht is open to the possibility of subsidizing carsharing for low-income residents going as far as signing and paying for their subscriptions. But he also says that while collaboration between the municipality and providers is important “it's up to the providers to make a business model, which is more attractive”. In The Hague one representative says that the municipality stimulates carsharing use by giving out coupons and vouchers. Meanwhile, the other representative thinks that spending on marketing instruments, such as vouchers for free rides, needs to be done by the providers who should see it as an investment, as they will gain more customers from it. If financial viability from the providers' perspective was not given, she says that she is not sure whether municipality subsidies could be an option. As the reason for this, she shares a concern that the municipality could not get too “involved on the commercial side”, saying that she thinks that granting turnover guarantees or subsidizing carsharing for users could be seen as “messaging with

the open market". When it comes to communication campaigns the representative says that this could be a joint effort shared between providers and the municipality as the municipality could be perceived as a more trustworthy messenger, because they are "not in for profit". Further, she suggests to rather engage with the providers by laying out ground rules and picking locations for the shared vehicles.

It also emerges from the interviews that a new vision of how to look at mobility seems to be developing. One of the representatives of The Hague was recently hired into a newly created role to look at how mobility can become more inclusive within the municipality. This involves a new approach where policymakers look at peoples' behaviour, preferences and needs to make mobility policy responding to that. As the representative says, there currently is not a lot of information about that yet, so they "need to look further into that and into [...] how people want to move around". There is now also a group of policy advisors from the municipalities of Amsterdam, Rotterdam, Utrecht, and The Hague which is focusing on inclusive mobility, "looking at ways to get a better view on the problem and how people experience it". The representative of The Hague, however, suggests that even more steps could be taken to allow for proper treatment of the issue: "In The Hague we have the department of mobility but there is also a department which is focusing on low-income people. [...] So, I think it would be better if this would be combined more in a way".

Social housing associations

The social housing associations, describe their mission to be about housing and making people with a low income feel comfortable in their houses and their neighbourhood. Further, all representatives agree that mobility is an important factor for the quality of life of their tenants. There are however differences in how much responsibility the representatives assume for this. On the one hand, the representative of Staedion says that they try to improve the mobility of their tenants, as the social housing association sees a responsibility beyond the provision of housing. She says that especially when it comes to large area developments, it is important to not only "focus on stones, but also try to connect it from the beginning with these social issues or the social needs". She also describes that the association has a lot of contact with their residents "to try to pick up on what their needs are", and once identified, they will try to respond to these needs themselves or forward the topic to the municipality. On the other hand, the representatives of Mitros and Domijn say that mobility is beyond their scope. But the representative of Domijn also adds that he thinks that it could be within the "scope soon, especially with the whole energy crisis right now" and that in some years mobility could be included in their development plans when they build new housing. The representative for Mitros on the other hand says that they do not see mobility needs as their responsibility and "investigating how our residents really see that, we don't really see it as our job to do". He emphasizes that they see it as their main task to "try to make housing as affordable as possible in order [...] to make sure that [tenants are] still able to pay their electricity bill, their mobility bill, the groceries".

He does however add that Mitros is responsible for providing parking spaces to their residents and that this also includes cooperation with carsharing providers. He explains this in the following way: "We as a housing association [...] want to build more housing units and if we can make sure that [we need] less parking spaces that means more housing units so [...] we see that as our responsibility". According to him, within the last two to three years it has become an opportunity for developing housing associations to reduce the number of parking spaces within a development when including carsharing, which Mitros made use of whenever possible. He explains that at the moment the contracts with the providers are still indirect via the constructors and that at Mitros they are not really aware of the conditions. But he adds that they want to create their own contracts with

providers so they can achieve “more structure [...] and perhaps also select a couple of providers [who they] trust and have a stronger relation with, in order to also improve the contract”. He also mentions that it will be important that the shared vehicles are then also being used. For this reason, he says that it should also be included in the contracts that the providers agree to introduce and explain the service to the social housing tenants.

The representative of Staedion remarks that while they invest in parking lots for their tenants, they cannot do everything themselves and that it is therefore important that the municipality also assumes their responsibility for providing mobility in transport-poor neighbourhoods. She says: “We see it as our responsibility to work on a solution, but that doesn’t mean that we also should pay for it”. According to her, particularly in the carsharing case, when there is a collaboration with a provider, the social housing association needs to pay a part of their investment, as the provider otherwise will not have a business case. She adds: “It’s not fair to put that on these social housing tenants because [...] they maybe have the money to use this facility, but we cannot ask them also to invest [in] that it is there”. The representative of Mitros shares this position saying that they need to “make sure that our tenants do not pay anything except for when they use the service because as a housing association, we try to represent tenants in that sense”. The representative of Domijn also believes that the introduction of carsharing to social housing tenants should be a shared responsibility with the municipality because “if you start sharing it means there’s more space to build and we also have a housing crisis”. The representative of Mitros believes that in light of the current energy crisis and rising energy poverty it is also the responsibility of the municipality to consider subsidizing not only the tenants’ energy bill but also their mobility bill.

The representative of Staedion remarks that there is a very large need to build more social housing, but the building process is slowed down because there are arguments with the municipality about how “to find the solution for the amount of parking lots” that have to be delivered within the development. This has become an extra problem for the social housing associations, as the municipality wants to decrease the amount of street parking. She also says that once parking spaces are built into a social housing complex, they are very difficult to be transformed later-on to be used for a different purpose. With trends towards less car ownership this will eventually lead to a lot of unused space in these buildings. Therefore, she mentions the idea “that we have this amount of parking lots we have to deliver, and we cannot find a solution on the housing plot, so we are going to collect these the leftovers and build a hub”. For Domijn parking is also an issue, as they are facing the need to reduce the number of parking spaces, while residents still own and use cars a lot. The representative of Domijn says that to his knowledge there have not yet been conversations with the municipality about this topic, but that in his opinion that should change. In The Hague, there is already some more collaboration with the municipality on mobility topics, but the representative of Staedion still mentions a concern that the municipality does not focus on mobility enough, for example within the current development of a new structural plan. She says: “We have some concerns, and we also try to put them on the agenda when we see there is a possibility to develop this area, to improve the mobility” and “we have to explain that [the need for including a lot of parking space] is really a problem for us and that [it] really stops the speed of development”. She also adds that it is important to discuss with the municipality which is the right perspective to tackle the issue: should the discussion even be about parking, or is better to focus on the mobility question? She adds that currently there is no real conclusion. Lastly, it is also striking throughout the interviews that all representatives have little information on the current availability and uptake of carsharing in their neighbourhoods or even in their housing complexes.

5.3. Discussion

The qualitative analysis found that factors which might lead to an above average supply of shared cars in transport-poor neighbourhoods include being located closer to the city centre and having recently seen large-scale development projects. The first of which emphasizes the insight gathered in the quantitative analysis, that remoteness is found to be the largest deterring factor for carsharing supply in transport-poor neighbourhoods. And the second, shows that the involvement of actors such as municipalities and social housing associations can in fact make a difference. While commonly mentioned, these findings have however not been consistent among the entire sample. The most notable deviation is Lunetten-Zuid, which is the best performing transport-poor neighbourhood in the dataset while being located further away from the city centre and not being subject to recent development projects, nor any other obvious explanatory factors. Additionally, the interviews show that while most municipality and social housing representatives do not know specific statistics of carsharing supply in transport-poor neighbourhoods they make correct assumptions about the lower performance of most of the sample neighbourhoods, indicating that they are aware of the issue. This matches with the fact that many of the underperforming sample neighbourhoods are already scheduled for future projects by the municipality targeting carsharing supply.

Looking for strategies that can improve the alignment of the carsharing offer with local mobility practices and needs in transport-poor neighbourhoods, a first step is to study the mobility practices. Employing the lens of social practice theory, when looking at materials, the most striking finding is that there is an inconsistency in the assumptions about the car ownership rates of households in transport-poor neighbourhoods. The providers and some municipality representatives state that car ownership in these neighbourhoods is low. As reducing car ownership is an important part of the providers' mission, this might lower their attractiveness leading to less supply of shared cars. The representatives of social housing and most of the municipality representatives do however believe that car ownership is high among residents in many of the sample neighbourhoods even though they dispose of a lower income. They reason this with a higher dependency on the car, as public transport fails to provide a viable alternative. Bringing light to this discussion could show carsharing providers that against their assumptions, car ownership can be substantially reduced even in transport-poor neighbourhoods with a predominantly low-income population.

| Municipality | Utrecht | The Hague | Enschede |
|---|---------------------|------------------------------|------------------|
| Average number of private cars per household | Zuilen-Noord: 0.8 | Venen, Oorden en Raden: 0.6 | Stevenfenne: 0.7 |
| | Lunetten-Zuid: 0.7 | Rond de Energiecentrale: 0.5 | Getfert: 0.6 |
| | Transwijk-Zuid: 0.4 | Heesterbuurt: 0.5 | De Bothoven: 0.5 |
| Average private car ownership in three sample neighbourhoods | 0.63 | 0.53 | 0.6 |
| Average private car ownership in the 10 neighbourhoods with the highest carsharing supply | 0.51 | 0.57 | 0.74 |

Table 10: The average number of private vehicles per household in different neighbourhoods

Interestingly, the quantitative analysis in the first part of this research found results that do not align with the intention voiced by the providers to predominantly offer carsharing in neighbourhoods

where car ownership is high. It shows that the more private cars the households within a neighbourhood own on average, the fewer shared cars can be found there. This could also be said to precisely be due to the presence of carsharing lowering car ownership rates, however it cannot be expected that at the current level of market saturation carsharing can already achieve such a measurable effect across the entire sample. Additional data analysis (Table 10) shows that in the three sample municipalities, car ownership is similar in the transport-poor sample neighbourhoods as in the neighbourhoods where most carsharing supply can be found. In Utrecht for example, the average number of private vehicles per household in the three sample neighbourhoods is 0.63, whereas in the ten neighbourhoods with the largest carsharing supply it is 0.51. The conclusion is therefore that those neighbourhoods currently served by carsharing are not generally distinguished by a higher-than-average car ownership rate and that the low car ownership in transport-poor neighbourhoods is a misperception which should not deter providers from supplying these neighbourhoods with shared cars.

Car ownership is described to take up a large share of transport-poor households' monthly budget yet remains common partly due to a lack of viable transport alternatives. This is however described to only be true for some trips, as residents do employ various transport modes, including public transport, biking, and a lot of walking. Regarding competences, financial literacy is identified as a big issue among households in transport-poor neighbourhoods. It is said that the complex cost structure of owning a second-hand car is leading many of them to making financially inefficient choices, as they tend to perceive car ownership as less expensive than it actually is. Regarding the meanings held by households in transport-poor neighbourhoods, it is said that for many their mobility radius and social circle turn small. This makes it less likely for them to hear of such innovations as carsharing through word of mouth and additionally a lack of trust in institutions makes it harder to approach them. The reasons mentioned for why car ownership is important to them are for one, the lack of other viable options, related to the fact that many people work shift and early or late hours, for example at hospitals or distribution centres, which they are not able to reach via public transport. But other reasons include habit, following cultural norms, valuing the reassurance of having their car always available, and needing it for visiting purposes. Lastly, status is mentioned by many to be an important reason for households to value their own car higher than a shared car.

Based on social practice literature, two intervention framings apply for introducing carsharing into households' mobility practices. The practice being travelling by car, the recrafting of practices is relevant for households that currently own a car. For them, the practice remains similar, with individual elements being adjusted from supporting car ownership to supporting carsharing. For the material element, this means that the car is no longer owned by the household, but instead they adopt a carsharing subscription. To be able to do so the carsharing infrastructure must be available, which is currently still insufficient in many transport-poor neighbourhoods. Other material elements supporting the practise such as smartphones are identified to be available in most households. Lastly, as carsharing is financially more interesting if the user applies a transport mix, public transport and biking infrastructure can also be identified to be supporting elements. However, especially public transport infrastructure is often unsatisfactory in these neighbourhoods, calling for improvements. Regarding the competences, a major factor holding back households from recrafting their practise is financial literacy. If households underestimate the cost of owning a car, this will hinder them from seeing their saving potential when adopting carsharing. Lastly, different meanings attributed to car ownership influence the likelihood of adopting carsharing. Those who need their car for their daily commute to work, might not benefit from adopting carsharing. However, for households who have a car for incidental trips like visits and who are also making use of other means of transportation, carsharing provides a great opportunity for financial savings. Seeing their car as a

status symbol or as a habit that they are not ready to give up could still hinder the recrafting of practices, but nicer vehicles, younger more experimentative generations and educative conversations with people they trust, such as at work or school might slowly change this.

The second approach, the substitution of practices aims at replacing one practice with another, therefore addressing households that currently do not own a car, and instead rely on other transport modes. From a material point of view, transport options are often scarce in transport-poor neighbourhoods, limiting the mobility of those who do not own a car significantly. Carsharing could therefore provide a clear benefit. Looking at competences, an important question will however be whether people who do not own a car will have a driver's licence. It can be argued that this could be seen as a good investment considering the benefits of enhanced mobility. However, this would still leave out some population groups, such as under-age or disabled individuals, emphasizing that carsharing should be regarded as one mobility alternative among many. Regarding meanings, carsharing will provide a clear opportunity to these households as it will allow them to access a larger mobility radius. Additionally, for them the habit of owning a car or the importance of status does not play a role and they would not need to use carsharing as a substitute for their daily commute, as they did not own a car in the first place. In conclusion, while the opportunities for carsharing might not apply to all households in transport-poor neighbourhoods, a substantial part of both those who currently own cars and who do not could benefit from the change in practices.

Analysing the reasons for which carsharing might still not be adopted by households in transport-poor neighbourhoods, seven barriers have been encountered: availability, compatibility, complexity, observability, relative advantage and trialability. The lack of availability is often mentioned to be the primary factor. This is in line with the previous finding that transport-poor neighbourhoods receive a disproportionately low supply of shared cars. It is assumed that this issue could slowly dissolve as the carsharing market grows and conditions such as population density and technology prices improve. It is however possible to speed up and assure this process with measures such as placing mobility hubs with shared vehicles in underserved neighbourhoods and adding carsharing to social housing carparks. Concerning the compatibility, one issue is the deposit payment. Solutions include charging a lower subscription fee, or for the municipality to sign subscriptions for low-income residents. Also, the low perceived status of driving a carsharing vehicle is a common issue. Providers could try to tackle this by offering vehicles with less branding on them, to better recreate the feeling of driving one's own car. Complexity is another barrier, leading to residents' hesitation towards carsharing use, as they have no experience driving new cars and are often unsure about the terms of use or how the mobile application works. This might be solved by making the carsharing proposition as easy as possible, providing more information near vehicles and organising information days.

Regarding observability, it is said that many residents are unaware of the carsharing offer. Mobility hubs are one solution to this as they increase visibility. But also, marketing is important, spreading information through big public campaigns, existing contact and by approaching people on the street. Concerning the relative advantage, a wrongly perceived disadvantage of carsharing relates to car owners underestimating what they pay for their private car and therefore perceiving carsharing as more expensive for them. This can be approached through educational campaigns and if carsharing is indeed found to be unaffordable for certain low-income users a subsidy can be considered. Finally, the trialability barrier emerges because potential users cannot test carsharing without signing up and paying the deposit fee. This can be approached by organising information days, and by handing out vouchers for first-time users. Barriers for which no solutions could be found include needing a car for the daily commute and not being able to have a driver's licence for reasons such as being too young or being disabled, striking again the importance of supporting multiple means of transport.

Among these potential solutions many approaches can be found that target adaptations in the business models of providers, such as diversifying vehicle locations, simplifying the terms of use and employing marketing campaigns targeting the residents of transport-poor neighbourhoods. However, mitigating barriers and building a user base in transport-poor neighbourhoods can be expected to still take time. As providers are commercial parties, it is however crucial for them to maintain the balance between their value creation, delivery, and capture to allow them to remain in operation (Teece, 2018). To facilitate this balance and allow for providers to make a social impact by serving transport-poor neighbourhoods while staying profitable as a business, it is therefore critical for municipalities to take supportive measures. Policy is therefore said to be essential for promoting the availability and uptake of carsharing in transport-poor neighbourhoods. This is also supported by the quantitative analysis showing a substantial difference in carsharing supply between neighbourhoods in different municipalities with otherwise similar conditions.

Turnover guarantees are an option to give providers the security of breaking even on their investment for the first months of supplying a transport-poor neighbourhood. Another option is offering the possibility for developers to decrease parking spaces in new developments such as social housing complexes when adding space for shared cars. This becomes especially interesting, as many municipalities now prohibit the use of public space for car parking in new developments. The introduction of parking permits lets the municipality guide the supply of shared cars towards more desirable locations by offering reduced permits to providers in selected areas. But parking permits can also be used for making car ownership less attractive. This however could lead to more problems, when applied in transport-poor neighbourhoods with insufficient alternatives. Another policy would then be better suited: a carsharing subsidy, where the municipality subsidizes a part of the carsharing cost for their low-income residents. Finally, parking envelopes are mentioned as a way of making providers commit to supplying, for example, every sixth car in a commercially less desirable area. Additionally, it is mentioned that municipalities should make policy focusing on improving public transport accessibility, improving the potential for multi-modal transportation.

Lastly, interviewees frequently mention a lack of knowledge, such as about the mobility needs and preferences of transport-poor households, a problem which is however said by some to be addressed by recently created roles and working groups that focus on inclusive mobility. But it is also said that knowledge is missing about the details behind carsharing agreements or concerning the root causes of transport-poverty. In addition to this lack of knowledge a lack of knowledge exchange is also mentioned, to enable a better integration of different issues such as mobility and transport-poverty and allow for the identification of joint solutions to issues faced by all stakeholders.

The reliability of this qualitative part of the research is slightly lower than that of the quantitative part as it relies on subjective data gathered in the interviews and uses a smaller sample. However, measures have been taken to assure satisfactory reliability of the results. The sample size is deemed large enough to provide sufficient reliability while still being small enough to allow for an in-depth analysis of the results. Additionally, the sample includes three different categories of interviewees in three different municipalities, covering different perspectives on the topic and allowing for a triangulation of the results. An interview guide is also used during all interviews, leading to similar questions being used with the various interviewees. The use of sample neighbourhoods additionally helps to provide the interviewees with a comparable notion of the transport-poor neighbourhoods at the centre of the research. The transparency of the analytical procedures is high, with the transcripts of all interviews as well as the codes made available. The fact that the interviews are conducted in a semi-structured way allows for a high validity of the outcomes, as it means that the researcher can start by asking short, open questions and react to the responses of the interviewee.

This, together with using neutral words, allows for in-depth results without leading the responses of the interviewees, reducing the risk of respondent bias. However, as all individuals experience subjective opinions and bias, the results are likely to contain a certain degree of bias and cannot be taken as entirely objective. Triangulating results with both the regression and survey results does however help to contain this risk. Lastly, the risk of researcher bias is addressed by discussing the sampling strategy with other researchers, using codes to analyse the data which are based on established scientific theories and by sharing the result of the analysis with the interviewees for feedback to avoid misinterpretation of their responses.

A shortcoming of this part is that no residents of social housing are interviewed. This owes for one to the fact, that various attempts to contact individuals who act as representatives of social housing tenants within various social housing associations, remained unsuccessful. But also, to the decision to not question individual social housing residents, as within the time constraints of the research, too few interviews are possible to achieve representativeness when studying individual mobility habits and needs. However, this can be considered to be compensated for by the analysis of the survey results in part three, where the specific experiences of low-income carsharing users are analysed in a much larger sample than would have been possible in the interviews. Another shortcoming of this research part is that many interviewees were lacking in-depth knowledge about the sample neighbourhoods. This made it hard to conclusively identify the factors which lead to the over- or under-performance of transport-poor neighbourhoods in terms of carsharing supply.

6. Survey analysis

6.1. Methodology

The last part of this research entails the analysis of secondary data in the form of survey results. The corresponding survey targeting users of carsharing was conducted in 2022 by the internship organisation Advier for the carsharing index published by CROW. The availability of this data presents the opportunity to derive further insights into the research topic. However, as the survey is not designed by the researcher, the questionnaire is not entirely aligned with the research question and therefore only some of the survey questions are evaluated here. The evaluation of these selected survey questions helps to answer two sub-questions. These sub-questions are for one, which motivations lead transport-poor individuals to adopting carsharing and secondly, what the mobility practices of transport-poor carsharing users are like. For the analysis of the results, the focus is therefore put on a subset of respondents who are identified to be transport-poor users by the income information provided by them.

The survey is designed by Advier to have a total of 33 questions. The survey data can be regarded as mixed methods, as questions are posed in a multiple-choice format making it predominantly quantitative, but a few of the questions leave the possibility for providing a written alternative answer as well adding a qualitative element (the draft questionnaire can be found in Appendix G). Surveys are distributed with the help of the carsharing providers GreenWheels, MyWheels, and Snappcar, who send them via email to all their registered users in the municipalities of The Hague, Rotterdam, Groningen, Delft and Amersfoort in March 2022. Filled-in questionnaires are then returned to Advier by May of the same year. The final dataset comprises a total of 387 filled-in questionnaires. From this original dataset some exclusions are made for this analysis. First of all, all questionnaires by respondents who answer that they only use peer-to-peer carsharing services are deleted, as this group is not interesting in the scope of this study which is focusing on B2C carsharing. Secondly, 44 questionnaires by respondents who say that they would rather not disclose their income category are also excluded as the identification of belonging to a low-income group is

crucial for this research. And lastly, the questionnaires of seven respondents that identify themselves as students are also excluded. Students can be expected to be less at risk of transport poverty, as for them having a low income is likely to be a temporary situation. This leaves a total of 306 questionnaires deemed of interest for this research. The income distribution of respondents is provided in Figure 11. Under the assumption that the survey is representative of the income distribution among carsharing users, this distribution shows that over one third of carsharing users have an annual gross household income of over EUR 70,000.

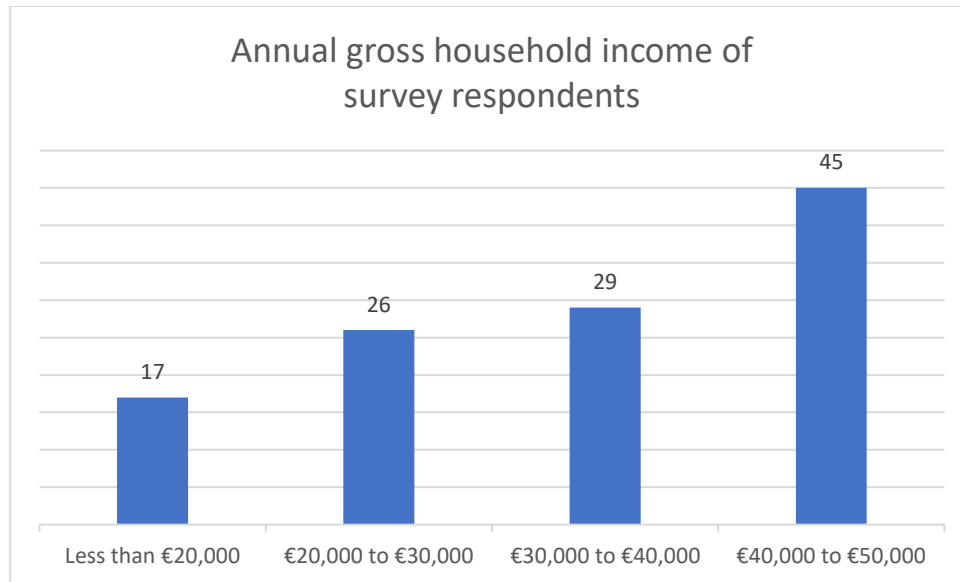


Figure 11: Income distribution of survey respondents by annual gross household income

The focus of this analysis is put on a smaller sample of the total dataset. This sample is generated by extracting all the questionnaires from those respondents who declared that their annual gross household income was below EUR 30,000. This sampling strategy is chosen to derive a sample that represents the carsharing users who can be characterised as transport poor. As transport poverty can be described among others by the characteristic of low income, this can be deemed a good approximation. The cut-off value of EUR 30,000 which is set by the multiple-choice answer options, can also be supported from a scientific point of view as it approximately coincides with the threshold for the annual gross income an individual is allowed to earn in the Netherlands to still be eligible for receiving a healthcare allowance from the government. This threshold is set at EUR 31,998 in 2022 (Ministry of Finance, 2022). The analysed sample therefore comprises the 43 questionnaires of those B2C carsharing users who participated in the survey that have a yearly gross household income below EUR 30,000, while not being students, making up 14.05% of the previous dataset and including a large age span of users aged 25 to 74. Of these 43 questionnaires, 17 belong to respondents with a yearly gross household income below EUR 20,000 and 26 to those with an income between EUR 20,000 and 30,000.

The resulting data is analysed for information on the motivations for adopting carsharing and the mobility practices of low-income users. Doing so constitutes an important addition to this research as it allows for the triangulation of previous findings with information obtained directly from the individuals in question. It also allows to gain insights specifically on those transport-poor households who are confirmed to be using carsharing. Table 11 shows what survey questions are analysed and how. It includes a total of 11 survey questions which are deemed to be relevant for this research. These survey questions are divided into five general topics with implications for answering the sub-

questions posed in this part of the research: motivations for using carsharing, carsharing habits, car ownership, the use of mobility alternatives and personal circumstances. The table also indicates that for four questions, additionally to evaluating the results of the sample group, a comparison is done between the average values of the low-income sample group and the average of those users in higher-income categories, to see whether considerable differences exist. As the survey has been conducted in Dutch, all questions and responses are translated into English.

| Topic | Questions | Research relevance | Comparison with higher-income users |
|------------------------|--|--------------------|-------------------------------------|
| Motivations | Why did you start to use carsharing? Why did you use carsharing for your last ride? | Motivations | |
| Carsharing habits | For what purpose did you use carsharing last? How often did you use carsharing in the past 12 months? | Mobility practices | |
| Private car ownership | How many private cars are there in your household? How many cars were there 12 months before you started using carsharing? How many cars would your household need if the carsharing offer would cease to exist? | Mobility practices | X X X |
| Mobility alternatives | Are you using public transport? Do you use a bike? | Mobility practices | X |
| Personal circumstances | How many adults/children live in your household? What is your employment situation? | Mobility practices | |

Table 11: Survey questions and their research relevance

6.2. Results

As the results contain confidential information of the internship organisation Advier, they cannot be published in this study. For more information contact Advier at info@advier.nl.

6.3. Discussion

First of all, the fact that a substantial number of low-income carsharing users can be identified within the sample, shows that carsharing can indeed present a good mobility alternative for certain transport-poor households. Concerning the motivations to adopt carsharing the analysis of the survey results shows that the main reasons cited by the low-income user group are gaining more flexibility and being able to rely on carsharing for emergencies, occasional rides, and specific reasons such as the transport of heavy objects or visits. Using carsharing is often found to be related to the users not owning a private car, for reasons such as not being able to afford it. This shows that the motivations of users are aligned with approaches for carsharing use that have been identified in the interviews to have the potential to lower costs when compared to car ownership, as most users do not intend to use carsharing for commuting or other regular trips. The most common reason for respondents to use carsharing for their last ride is the unavailability or inefficiency of public transport and the transport of heavy baggage. The first of which confirms one of the main benefits of carsharing suggested in the interviews: carsharing can offer a mobility alternative to people in neighbourhoods where public transport is scarce, effectively increasing their mobility radius.

Regarding the carsharing practices applied by transport-poor carsharing users, when asked about the purpose of their carsharing trips respondents mostly mention visiting someone or somewhere, going for a drive or a walk, going shopping or driving to go out and practice sports or other hobbies. Interestingly, even though a majority of respondents have a job and around one fifth of them have children, using carsharing for the purpose of reaching work, childcare or education are not common.

This again suggests, that carsharing is indeed used predominantly for incidental leisure trips, rather than routine drives and coincides with the insight gathered in the interviews that carsharing will not be attractive for daily commuters. It also shows on the one hand, that carsharing is often used to access leisure activities and can therefore help to increase the quality of life of low-income users who are substituting their practice. On the other hand, the insight that for most low-income respondents these routine trips can be done without using a car shows that carsharing adoption can lead to a cost reduction potential when compared to car ownership when recrafting the practice. The fact that almost all carsharing users also regularly use their bike and public transport, shows their readiness to combine different means of transport in order to fulfil their mobility needs. Based on the findings of both the interviews and survey results it can therefore be assumed that low-income carsharing users employ a variety of transport modes, relying on carsharing mainly when it is the only efficient or available option for a specific trip. Most respondents also state that they use carsharing either at least once a month or at least once every six months with very few saying that they use it as often as once a week or more regularly, again confirming that the usage among low-income users is mostly limited to incidental trips. The 20% of low-income carsharing users that do state that they are intending to use carsharing more regularly almost exclusively belong to the second lowest income category of EUR 20,000 to EUR 30,000 a year, indicating that they might feel they have more financial flexibility to afford regular carsharing. They also more commonly state reducing their travel time as a motivation for carsharing use, which supports this interpretation.

Focusing specifically on the relationship between carsharing and car ownership it is found that only a small fraction of low-income carsharing users own a car. When looking at the car ownership of respondents 12 months prior to their adoption of carsharing, it can be seen that car ownership was a lot higher, showing a negative correlation between the adoption of carsharing and private car ownership. This could either be due to people giving up their private car and as a result adopting carsharing or due to people who adopt carsharing and give up their private car as a result. It is also interesting that car ownership at both points in time is significantly higher for the income category with the very lowest income, compared to those with an income between EUR 20,000 to 30,000. This could be interpreted to show that those with the lowest income are most reliant on their car, either because of poor public transport accessibility in the places they live or the nature of their jobs requiring them to work shifts. When looking specifically at the reduction of car ownership between these two points in time, it becomes clear that the change is large for all income categories and that there are no substantial differences based on income. This underlines the potential, which was already mentioned in the interviews, for carsharing providers to comply with their mission of “taking cars off the streets” also when serving low-income individuals. Lastly, opposing the actual car ownership numbers which are considerably higher for the high-income users, the need for a private car in the case that the carsharing offer of their provider would cease to exist is stated to be slightly higher among the lowest income category compared to the highest one. It can therefore be concluded that the theoretical need among the lowest income category seems to be much higher than is shown in real car ownership rates. This hints at the carsharing offer balancing out what might otherwise be a limitation in the mobility options of low-income households based on factors such as the lower public-transport accessibility in their neighbourhoods and the lower affordability of car ownership. It therefore shows the potential of carsharing to foster social inclusion.

Concerning the reliability of this part of the research, the possibility to use secondary data means that a large number of datapoints were available in the dataset. This also leads to a sufficiently large sample size of low-income carsharing users, especially when considering the specificity of the sample delineation. Results are gathered from five different Dutch municipalities, assuring that they are not skewed by certain conditions in place in one locality. The results can therefore be assumed

to approximate the larger population of low-income carsharing users. A replication of this part of the research utilizing the same sample definition can therefore be expected to lead to similar results. Further, the survey questions and multiple-choice answers were the exact same in each of the questionnaires and are made publicly available in the Appendix of this paper, so the survey itself could be easily replicated. The secondary data used is however subject to confidentiality and therefore only accessible through the internship organisation Advier. The sub-questions addressed in this part of the research seek to find the motivation for carsharing use and the carsharing practices of low-income users. As the survey conducted by Advier entails a wide variety of questions, a subset of questions could be identified and selected that respond to these research questions, leading to high validity. This is also helped by the fact that it was possible for the researcher to give their feedback on the draft survey questions before the distribution of the survey. Limitations correspond to the depth that can be reached in surveys, as for example the question targeting the purpose of carsharing usage is limited to the respondents' last use of carsharing. Additionally, it can be said that multiple-choice answers might introduce bias, as they guide the respondents' answers. This risk is however reduced by allowing the respondents to give a different, written response.

As the survey is sent by the providers to all of their users, the sampling method is random sampling. This increases validity as it ensures that the researchers' bias is not affecting the sample selection. However, in this case it can be observed that random sampling also introduces a bias as survey respondents are overrepresenting high frequency users of carsharing. When comparing the average frequency of carsharing use as provided by the respondents with the numbers provided to Advier by the providers who were involved in distributing the survey, it is striking that the survey strongly overrepresents those users who say that they use carsharing "at least once a week" and "at least once a month". In the survey this is indicated by 60% of the respondents, whereas in the provider data only less than 10% of users fit this description. The category of users who use carsharing "at least once every half year" is depicted most accurately with survey and provider values around 30%. Lastly, users who use carsharing "at least once a year" or "almost never" are underrepresented by the survey, as they make up less than 10% of respondents whereas in provider data, they make up almost 65%. This discrepancy can be attributed to more regular carsharing users being more interested or willing to participate in a carsharing survey. Further, basing the sampling strategy on the household income of the respondents was the best possible alternative considering the data collected by the survey. However, it should be said that this leads to a sample that is non homogenous, as varying context such as the differing household sizes can put this income data in a different perspective, where some households might be more transport-poor than others. One measure taken that can limit this effect, is the exclusion of students from the sample. Lastly, as the insights gathered here concern only those transport-poor individuals who are using carsharing, their motivations and practices cannot be generalised to the entire transport-poor population, as findings are skewed towards representing those households for which carsharing provides a good solution. They can however show the context in which carsharing can be beneficial. The respondents can also not be traced back to living in those neighbourhoods previously identified as transport-poor, being approximated to represent transport-poor households only by their income information.

7. Conclusion

There are transport-poor neighbourhoods present throughout municipalities in the Netherlands, where residents with a low average household income face reduced public transport accessibility and longer distances to facilities. To address this issue, this research answers the question whether B2C carsharing can be a beneficial and viable mobility solution for these neighbourhoods and which strategies can help to make this happen.

Many households in transport-poor neighbourhoods are found to be lacking satisfactory mobility options. As public transport is often scarce, with inefficient, expensive, or unavailable connections, households rely on alternatives such as biking and walking, limiting their mobility radius and thereby their opportunities and quality of life. An option allowing for a larger mobility radius is car ownership, which while common, takes up a large share of low-income households' monthly budget. The survey results also suggest that there is an unmet need for car ownership among low-income households, which they might not be able to afford to fill. Carsharing can therefore provide many transport-poor households with benefits in one of two ways. For those who own a car, recrafting their practice to carsharing, thereby giving up on their car and adopting carsharing, can lower their costs. At least, this is the case for those who do not rely on a car for regular trips such as commuting, as carsharing can mostly bear financial benefits for those who use it incidentally. For those who do not own a car, substituting some of their mobility practices with carsharing can expand their mobility radius by allowing them to travel to places that were previously inaccessible. This is however not yet happening on a large scale due to the presence of several barriers. The first barrier being availability, the regression analysis shows that transport-poor neighbourhoods with the characteristics of low public transport accessibility and long distances to facilities, currently receive a disproportionately low share of carsharing supply. But findings of the regression and survey analysis show that carsharing is already well-supplied in some transport-poor neighbourhoods and adopted by a share of low-income users who employ the service in an appropriate way to lower their mobility costs and help them to access activities that enhance their quality of life, by using carsharing predominantly for incidental leisure trips to locations that are hard to reach by public transport. This proves the potential benefits that could be achieved by supplying carsharing in transport-poor neighbourhoods.

Most transport-poor neighbourhoods still not being served can be traced back to the fact that most carsharing vehicles are currently placed by providers. While the providers do not specifically avoid transport-poor neighbourhoods, multiple factors do play into making them less attractive. Carsharing providers say that they choose their locations according to two principles. First, they need to fit their companies' mission of reducing car ownership and second, they have to be profitable. The first one hinders the supply of shared cars to transport-poor neighbourhoods as providers perceive car ownership rates in these areas to be low. This study however shows that car ownership rates in transport-poor neighbourhoods are comparable to those of neighbourhoods with high carsharing supply and that carsharing adoption is correlated with a substantial drop in car ownership, which is comparable across all income categories. But the financial profitability is more unclear. Carsharing can deliver a benefit to many transport-poor households suggesting high adoption potential. But as multiple barriers apart from availability are still identified in transport-poor neighbourhoods it is currently easier for providers to supply other neighbourhoods, such as those in the city centre. The long-term ambition of providers is however to continuously expand the area they serve, which is assumed to be supported by changing market conditions, such as a rise in population density and a decrease in the cost of technologies used. It can therefore be expected that this process of organic growth will eventually also reach transport-poor neighbourhoods. However, regression analysis finds that 65% of the sample neighbourhoods are still not served by carsharing.

Also, mitigating the barriers and building a user base in transport-poor neighbourhoods can be expected to take time. Accelerating this process and helping to facilitate the balance between value creation, delivery, and capture in the business models of providers is therefore a crucial task for municipalities, in order to provide mobility solutions to transport-poor households that need them now. The potential impact of this involvement is emphasized by the regression analysis showing substantial differences in supply between transport-poor neighbourhoods located in different municipalities with otherwise similar characteristics.

Multiple strategies can be recommended for making carsharing in transport-poor neighbourhoods attractive for residents as well as providers. An important instrument which municipalities can use is policy. Policies can increase the availability of carsharing in transport-poor neighbourhoods through mandating supply such as by introducing parking envelopes, which means telling the providers to supply one car in a transport-poor neighbourhood, for every set number of cars supplied in other places. But responding to the profitability concern of providers, municipalities can also create financial incentives such as turnover guarantees, where they cover the losses incurred during the first months by shared vehicles supplied in certain locations. Parking permits can also be a way to achieve this, by offering providers cheaper permits in desired locations. This can be applied in combination with transport hubs, where the municipality can select locations in transport-poor neighbourhoods and offer providers to place their car at a reduced rate. Hubs can also help to increase the observability of carsharing for those people who are currently unaware of the option and can mitigate compatibility and complexity barriers by providing potential users with additional information or by including a concierge service who helps people with questions. As the carsharing subscription and the related deposit payment are found to be a barrier, municipalities can also consider introducing a subsidy on carsharing for those with a low-income, which could cover the deposit rate and possibly lower the cost of carsharing for low-income households.

Further, an important way for municipalities to get involved is by doing communication. They can use their position as a third party and launch marketing campaigns to increase the awareness of carsharing among the residents of transport-poor neighbourhoods, but also their understanding of the terms and how to maximise potential benefits. Hosting introduction days and handing out vouchers in transport-poor neighbourhoods can also allow people to familiarise themselves with the service. But on top of that, it would be advisable for municipalities to focus on increasing the financial literacy among transport-poor households. It is found that currently many households underestimate the total costs they incur because of car ownership, leading them to perceive the costs of carsharing to be relatively higher. Educating transport-poor households on the real cost of car ownership and their saving potentials when switching to carsharing is therefore essential.

Public transport accessibility can improve the viability and benefits of carsharing in transport-poor neighbourhoods. It is therefore in the scope of this paper to recommend municipalities to place significant attention on improving public transport infrastructure in transport-poor neighbourhoods and assuring its affordability for everyone. This can however not be regarded as an alternative route to supporting carsharing, as it is unlikely that public transport can in the near future replace all car transport. However, the two should be seen as complements, with better public transport accessibility increasing the possibilities for residents of transport-poor neighbourhoods to employ a transport-mix. The potential for this is shown by the survey finding that low-income users mainly use carsharing when no public transport is available. Improving connections will therefore lower the number of times they need to use carsharing, making it more affordable and more environmentally sustainable at the same time. It will also increase the likelihood of people being able to do their routine trips using public transport, opening up a pathway for the recrafting of their practice from

car ownership to carsharing for more people. And lastly, it is essential for those who for various reasons do not have a driver's licence, such as people who are under-age or have a disability. For very similar reasons municipalities are also advised to consider providing residents of transport-poor neighbourhoods with bikes.

Additionally, closer cooperation between the stakeholders can allow them to share their diverse knowledge on the mobility needs and barriers present, as well as the root causes of the issues and derive comprehensive strategies for solutions. This includes better communication even within the municipalities, as departments focusing on mobility and the social implications of mobility could develop synergies when intertwined more closely. But it also suggests that the municipality could initiate a deeper conversation with providers and social housing associations. A good starting point for the latter will be that before the backdrop of the current housing crisis, social housing associations are facing a large need for creating additional housing. However, high parking pressure and the related need to create larger parking spaces within the development make it increasingly hard for them to comply with the growing need for housing development. As carsharing policy can give developers the opportunity to reduce the number of parking spaces in a development when shared cars are included, it can help to reduce this pressure on the social housing associations. Close cooperation with municipalities and carsharing providers is therefore also important from the perspective of social housing organisations. They can do their part when it comes to the realisation of the parking spaces, taking ownership of conversations with providers which currently are often led by property developers and opening up communication channels with their tenants. For the latter, they can make use of the personal connections of their tenant consultants.

Recommendations for providers include adapting their business model, such as by making their proposition as simple as possible when it comes to signing up, payment, terms and conditions, and the actual usage of the car. But also, with regard to a common barrier being the lack of status when driving a shared car, improvements can be made, such as reducing the branding on the outside of a shared car, to better recreate the feeling of using one's own vehicle. Further, while supplying cars in transport-poor neighbourhoods aligns with the mission of reducing car ownership, providers might also rethink their mission to make it more nuanced. This means that they could consider whether the social equity impact of providing car mobility on an incidental basis to those transport-poor households who are otherwise considerably limited in their mobility radius and thereby disadvantaged in society, is also an aim worth supporting. Lastly, it should be added that pilot projects are already being run or being planned by some municipalities and providers in a number of transport-poor neighbourhoods. While this is an important step, these pilot projects are however still relatively scarce and often focused on the provision of mobility hubs. Similarly, carsharing is already included in some new social housing developments, but overall awareness, availability, and usage of this option within the sector remains questionable.

To conclude, while B2C carsharing supply is currently low in most transport-poor neighbourhoods, it does bear the potential to become a beneficial mobility solution for many, promising to decrease residents' spendings on mobility or increase their mobility radius. This can have a considerable social equity impact, as it can improve the quality of life of residents and reduce the inequalities reinforced by transport-poverty. To facilitate the viability of this solution, the previously mentioned strategies to mitigate current barriers can be applied by the municipalities, social housing organisations and providers. They will in the following be briefly summed up.

Recommendations for municipalities:

- Introducing policies that incentivize supply in transport-poor neighbourhoods: turnover guarantees, targeted parking permit price reductions for providers, reduced parking space requirements for developments with carsharing spaces
- Introducing policies mandating supply: parking envelopes
- Introducing policy to facilitate demand: carsharing subsidies for low-income residents, potentially including the coverage of the deposit
- Creating mobility hubs in transport-poor neighbourhoods addressing the local needs
- Undertaking marketing efforts, including campaigns addressing financial literacy
- Improving public transport and biking infrastructure in transport-poor neighbourhoods
- Increasing cooperation and knowledge exchange with providers and social housing associations

Recommendations for social housing associations:

- Inclusion of shared cars in new developments
- Increasing involvement in conversations currently held between providers and developers
- Engaging in cooperation with municipalities and providers to share knowledge and formulate strategies
- Acting as an information transmitter and facilitator between the municipalities or providers, and their tenants, such as by involving tenant consultants

Recommendations for providers:

- Refinement of carsharing proposition to be less complex and better approximate the experience of car ownership, for example by having less branding on cars
- Continued participation in pilots and cooperation with municipalities and social housing associations to gather and share more knowledge
- Rethinking of alignment of serving transport-poor neighbourhoods with mission, for reasons of car ownership reduction and social equity potential
- Provision of educational communication to households in transport-poor neighbourhoods and social housing

As reliability and validity of the results are discussed in each separate part of the research it only remains to say that both measures are again improved when it comes to responding to the overall research question. This is due to the convergence of results which are obtained from three different research parts, each making use of a distinct methodological approach and different data sources, while analysing related sub-questions. Dissonances in information encountered in one research step, such as the contradicting perspectives of car ownership in the interviews, are clarified by the evaluation of data collected in other steps and the triangulation of the results shows that they do indeed align to provide one cohesive answer to the research question. The most important limitations of the final research output are for one, that this analysis excludes peer-to-peer and cooperative carsharing. Setting this delineation is necessary to allow for an in-depth analysis and the formulation of useful recommendations targeting B2C carsharing. However, the potential of peer-to-peer and cooperative carsharing for benefitting transport-poor neighbourhoods should also not be underestimated. And lastly, while the mobility practices of transport-poor households are at the centre of this research, this group does not directly contribute their experiences to the research. Their practices, needs, barriers and carsharing use are however on the one hand analysed through the observations of other stakeholders who based on their roles hold significant legitimacy for

sharing observations and assumptions on this group. On the other hand, information is gathered from a survey addressing transport-poor carsharing users, thereby providing first-hand insights from a sub-group of those transport-poor households, who do already use carsharing.

There are various theoretical implications of this research. First, it is shown that adoption and social practice theory apply well to the context of studying carsharing adoption in transport-poor neighbourhoods. The study also shows how the theories can be combined as barriers to adoption emerge from practices and potential pathways for change can be identified using the intervention framings. With regards to the adoption theory all five barriers are identified to be relevant and are extended by a sixth barrier to capture the prohibitive effect of the unavailability of supply on adoption. Concerning the relative advantage barrier, this research also employs the notion that the relative advantage can be real, but could also be wrongly perceived by individuals, adding additional depth to the concept. Regarding the social practice theory, the three elements of materials, competences, and meanings, are shown to adequately cover the aspects of the practice of carsharing and the intervention framings of recrafting and substituting practices delivered helpful approaches to envisioning pathways for change. A contribution of this thesis is thereby also the joint application of two intervention framings to arrive at the same outcome, each addressing potential users of carsharing who currently employ different mobility practices. The study also highlights the importance of balancing changes in the business models of companies and the potential for municipalities to support the business case of commercial providers in order to drive positive social impact while maintaining profitability. Lastly, this study extends current literature on carsharing in the Netherlands by conducting a neighbourhood-level comparison of a large dataset of 30 municipalities. It can therefore show a measurable impact of the municipal context on neighbourhood performance.

Finally, this leads to the directions for future research. Looking at the limitations as starting points, it would be interesting for future research to also analyse the current status and potential of other carsharing business models, notably peer-to-peer and cooperative carsharing, in addressing transport-poor neighbourhoods, as well as strategies to support their roll-out. This could use a similar research layout that was applied here. Further, it will be interesting to confirm and enrich the insights on the mobility practices, needs and barriers to adoption of households in transport-poor neighbourhoods with data on first-hand experiences by conducting a qualitative study with a large sample of representatives belonging to these households. Moreover, it will be interesting to analyse more closely the success of the specific strategies recommended here, when applied by municipalities, social housing associations and providers. As more pilots are starting to be conducted in transport-poor neighbourhoods such as by the municipality of Utrecht, examining the success of these projects as well as the experience gathered will be interesting. Further, this study focuses on the under-proportional supply of carsharing in transport-poor neighbourhoods with a high share of low-income population. However, as carsharing is said to be predominantly adopted by those with a higher income and above-average educational attainment it could also be interesting to analyse if there are specific barriers in place concerning households in the middle-class. With rising fuel prices and increasing parking pressure, car ownership might increasingly be perceived as a barrier by them as well, possibly leading to new opportunities for providers. Lastly, for reasons such as the lower population density carsharing is not expected to provide a viable mobility alternative for rural areas. However, these places are also facing transport-poverty. Doing research on potential mobility solutions for rural neighbourhoods is therefore important.

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Appendix A: Carsharing cost compared to private ownership

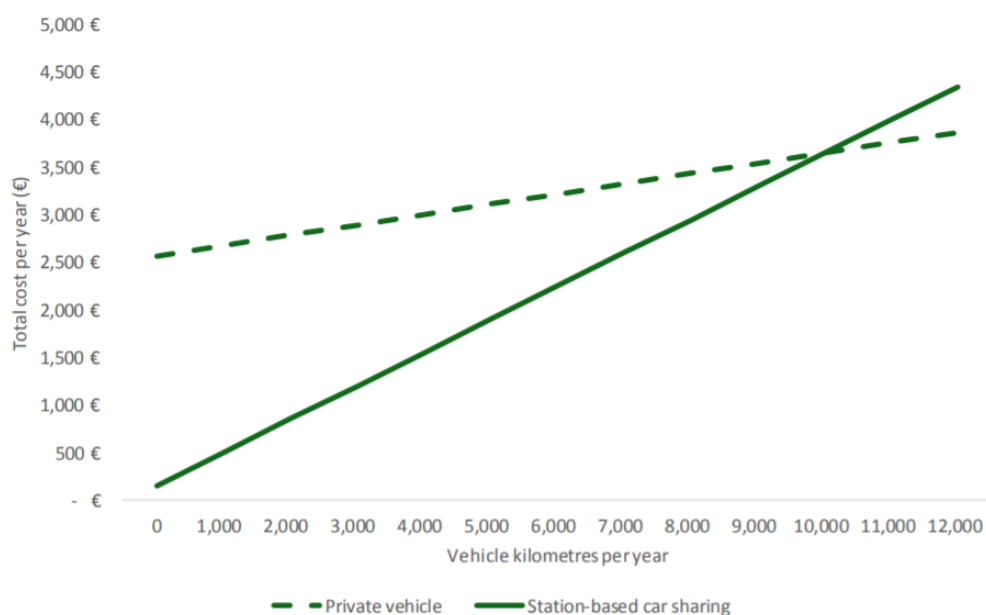


Figure A1: Average cost comparison: driver-owned car vs. carsharing (Circular Impacts, 2018, p.15)

The above figure shows two graphs representing the cost of private vehicle ownership and station-based carsharing on the X-axis and how they develop depending on the vehicles kilometres per year (km/y) that are driven. What can be seen is that up until 10000 km/y carsharing is the less cost-intensive alternative. At 10000 km/y the graphs then intersect showing that for those who drive more, a private vehicle will be more economical. This dynamic occurs because of the fixed costs that a car owner needs to pay regardless of the kilometres driven (BCS, 2017). This calculation has been computed for the German market. The costs for the driver-owned car are calculated for one of the 10 cheapest compact cars available in Germany using the ADAC car cost calculator. The carsharing cost is the standard rate of a provider of station-based carsharing, including the fixed costs for registration, security, and the membership price. The values used for calculating the costs at 8000 km/year are shown in the table below (BCS, 2017).

| | Driver owned cars | Car sharing |
|--------------------------------|-------------------|-------------|
| Fixed costs | €960 | €176 |
| Costs for repair | €298 | - |
| Operating costs / travel costs | €605 | €2,780 |
| Loss in value | €1.620 | - |
| In total | €3,483 | €2,956 |

Table A1: Average annual costs for a driver-owned car and carsharing at 8000 km/y (Circular Impacts, 2008, p.15)

As this calculation is done using values for the German market the results cannot be expected to be identical for the Netherlands. However, the countries are geographically adjacent, with similar cost structures for car ownership and carsharing structures, meaning that this analysis is still valuable for understanding the Dutch market, even though the exact numbers might differ from those in Germany.

Appendix B: Data descriptives

| Variable | statcode | municipality_name | gm_code |
|----------|-----------|-------------------|-----------|
| Length | 2030 | 2030 | 2030 |
| Class | character | character | character |
| Mode | character | character | character |

Table B1: Descriptives of character variables

| Variable | sharedcars | population | population_density | household_size | unemployment_ben_p | low_income_p |
|----------|------------|------------|--------------------|----------------|--------------------|--------------|
| Min. | 0.0000 | 155 | 12 | 1.100 | 0.00000 | 0.000 |
| 1st Qu. | 0.0000 | 1060 | 3085 | 1.800 | 0.01135 | 2.800 |
| Median | 0.0000 | 1815 | 5667 | 2.100 | 0.01458 | 5.900 |
| Mean | 0.9961 | 2408 | 5904 | 2.115 | 0.01440 | 7.611 |
| 3rd Qu. | 1.0000 | 3089 | 8189 | 2.400 | 0.01770 | 11.100 |
| Max. | 30.0000 | 15915 | 23592 | 3.800 | 0.05882 | 80.300 |

Table B2: Descriptives of numeric variables (1)

| Variable | household_vehicles | low_edu_p | med_edu_p | high_edu_p | PTAI | distance |
|----------|--------------------|-----------|-----------|------------|---------|----------|
| Min. | 0.1000 | 0.7678 | 5.714 | 0.00 | 0.000 | 0.1750 |
| 1st Qu. | 0.6000 | 14.2857 | 26.346 | 17.89 | 5.198 | 0.4750 |
| Median | 0.8000 | 19.8916 | 30.915 | 25.14 | 13.558 | 0.6000 |
| Mean | 0.8388 | 20.3265 | 30.537 | 27.52 | 19.464 | 0.7623 |
| 3rd Qu. | 1.2000 | 25.5932 | 34.792 | 35.49 | 25.321 | 0.8250 |
| Max. | 2.3000 | 67.6923 | 90.526 | 84.54 | 272.420 | 5.9250 |

Table B3: Descriptives of numeric variables (2)

Appendix C: Correlation tables

| Variable | sharedcars | population | population_density | household_size | unemployment_ben_p | low_income_p | household_vehicles | low_edu_p | PTAI | distance |
|--------------------|-------------|-------------|--------------------|----------------|--------------------|--------------|--------------------|-------------|-------------|-----------|
| sharedcars | 1.00000000 | 0.36257601 | 0.37867189 | -0.23184800 | -0.02905154 | 0.07834126 | -0.2327558 | -0.22883166 | 0.39481377 | -19975802 |
| population | 0.36257601 | 1.00000000 | 0.29087810 | -0.01971663 | 0.02078850 | 0.11521144 | -0.1886333 | 0.04229265 | 0.04239916 | -26917922 |
| population_density | 0.37867189 | 0.29087810 | 1.00000000 | -0.35147758 | 0.10418449 | 0.30153119 | -0.4716216 | 0.00376951 | 0.44736403 | -55870289 |
| household_size | -0.23184800 | -0.01971663 | -0.35147758 | 1.00000000 | -0.12620865 | -0.45789334 | 0.5411507 | 0.03487510 | -0.48409568 | 36917622 |
| unemployment_ben_p | -0.02905154 | 0.02078850 | 0.10418449 | -0.12620865 | 1.00000000 | 0.13073093 | -0.0757603 | 0.11537247 | 0.05549431 | -14064368 |
| low_income_p | 0.07834126 | 0.11521144 | 0.30153119 | -0.45789334 | 0.13073093 | 1.00000000 | -0.3604770 | 0.44942422 | 0.22095087 | -21999267 |
| household_vehicles | -0.23275584 | -0.18863325 | -0.47162161 | 0.54115071 | -0.07576030 | -0.36047698 | 1.00000000 | 0.02372380 | -0.39908029 | 48863090 |
| low_edu_p | -0.22883166 | 0.04229265 | 0.00376951 | 0.03487510 | 0.11537247 | 0.44942422 | 0.0237238 | 1.00000000 | -0.25197051 | 2527465 |
| PTAI | 0.39481377 | 0.04239916 | 0.44736403 | -0.48409568 | 0.05549431 | 0.22095087 | -0.3990803 | -0.25197051 | 1.00000000 | -32886826 |
| distance | -0.19975802 | -0.26917922 | -0.55870289 | 0.36917622 | -0.14064368 | -0.21999267 | 0.4886309 | 0.02527465 | -0.32886826 | 100000000 |

Table C1: Correlation table for negative binomial regression model without dummies

| | sharedcars | population | population_density | household_size | unemployment_ben_p | low_income_p | household_vehicles | low_edu_p | PTAI | distance |
|--------------------|---------------|--------------|--------------------|----------------|--------------------|--------------|--------------------|--------------|---------------|--------------|
| sharedcars | 1.000000000 | 0.362576010 | 0.378671885 | -0.231847996 | -0.0290515445 | 0.078341261 | -0.232755842 | -0.228831662 | 0.3948137653 | -0.199758017 |
| population | 0.3625760102 | 1.000000000 | 0.290878098 | -0.019716629 | 0.0207885005 | 0.115211445 | -0.188633250 | 0.042292645 | 0.0423991603 | -0.269179219 |
| population_density | 0.3786718854 | 0.290878098 | 1.000000000 | -0.351477583 | 0.1041844912 | 0.301531192 | -0.471621613 | 0.003769510 | 0.4473640293 | -0.558702895 |
| household_size | -0.2318479957 | -0.019716629 | -0.351477583 | 1.000000000 | -0.1262086478 | -0.457893338 | 0.541150707 | 0.034875100 | -0.4840956806 | 0.369176225 |
| unemployment_ben_p | -0.0290515445 | 0.020788501 | 0.104184491 | -0.126208648 | 1.000000000 | 0.130730935 | -0.075760301 | 0.115372473 | 0.0554943118 | -0.140643683 |
| low_income_p | 0.0783412613 | 0.115211445 | 0.301531192 | -0.457893338 | 0.1307309348 | 1.000000000 | -0.360476983 | 0.449424224 | 0.2209508736 | -0.219992669 |
| household_vehicles | -0.2327558422 | -0.188633250 | -0.471621613 | 0.541150707 | -0.0757603014 | -0.360476983 | 1.000000000 | 0.023723804 | -0.3990802943 | 0.488630905 |
| low_edu_p | -0.2288316620 | 0.042292645 | 0.003769510 | 0.034875100 | 0.1153724731 | 0.449424224 | 0.023723804 | 1.000000000 | -0.2519705068 | 0.025274648 |
| PTAI | 0.3948137653 | 0.042399160 | 0.447364029 | -0.484095681 | 0.0554943118 | 0.220950874 | -0.399080294 | -0.251970507 | 1.000000000 | -0.328868264 |
| distance | -0.1997580173 | -0.269179219 | -0.558702895 | 0.369176225 | -0.1406436833 | -0.219992669 | 0.488630905 | 0.025274648 | -0.3288682637 | 1.000000000 |
| Groningen | -0.0027838039 | 0.043603247 | -0.003362277 | -0.080872579 | 0.0001525033 | 0.068895964 | -0.045108534 | -0.143744394 | 0.0626789097 | 0.053941001 |
| Almere | -0.0337602092 | 0.162430759 | -0.061179508 | 0.088313077 | 0.1123837717 | -0.039244377 | -0.039256865 | 0.040020814 | -0.0300719933 | 0.047200913 |
| Leeuwarden | -0.0727200634 | -0.072359498 | -0.061555407 | -0.075391231 | 0.1096814177 | 0.059719302 | -0.020707317 | -0.032094908 | 0.0669740079 | 0.070128529 |
| Emmen | -0.0551665274 | 0.017307580 | -0.157518983 | 0.057717252 | 0.0575656586 | -0.021687592 | 0.135936946 | 0.095968479 | -0.0994869618 | 0.140926431 |
| Deventer | -0.0486332152 | -0.053853961 | -0.046270117 | 0.032161318 | 0.0718294302 | -0.021022710 | 0.023014555 | -0.008188853 | 0.0008696698 | 0.039461015 |
| Enschede | -0.0567361698 | 0.012418178 | -0.080791757 | 0.003977069 | -0.0268635433 | 0.063894611 | 0.049521485 | 0.042770718 | -0.0876075457 | 0.009050162 |
| Zwolle | -0.0221844935 | -0.026384056 | -0.062673219 | 0.012597373 | 0.0461974243 | 0.001802761 | -0.037453652 | -0.053246921 | -0.0073136691 | 0.053860488 |
| Apeldoorn | -0.0567361698 | 0.011770261 | -0.122825941 | 0.069041348 | -0.0311590584 | -0.056724007 | 0.090940464 | 0.016117219 | -0.0549390396 | 0.068988721 |
| Arnhem | -0.0117687044 | -0.016266266 | -0.010473287 | -0.068062157 | 0.0615977134 | 0.139329378 | -0.041731567 | 0.031903379 | 0.0148564319 | -0.013618114 |
| Ede | -0.0470000473 | -0.033936572 | -0.104912604 | 0.160903671 | -0.1408138988 | -0.083081628 | 0.113779113 | 0.027827053 | -0.0938768015 | 0.103826433 |
| Nijmegen | 0.0645843755 | 0.157488054 | -0.026364262 | -0.081479784 | 0.0065434653 | 0.048401458 | -0.045734540 | -0.048237849 | -0.0126335053 | -0.015143716 |
| Amersfoort | -0.0139599079 | -0.117394937 | 0.044686791 | 0.073380498 | 0.0136674311 | -0.037688454 | -0.017011668 | -0.068388130 | 0.1903475557 | -0.055769211 |
| Utrecht | 0.5559985123 | 0.131790634 | 0.167818800 | -0.077305495 | -0.0501960256 | 0.033039190 | -0.131702286 | -0.147831579 | 0.2383327870 | -0.085102707 |
| Alkmaar | -0.0420441011 | -0.039237606 | -0.030156805 | 0.008051140 | -0.0500783031 | -0.030857786 | 0.013823518 | 0.005690814 | -0.0123439100 | 0.028444472 |
| Haarlem | -0.0045469427 | -0.067315930 | 0.210361021 | 0.001613661 | -0.0233216353 | -0.036713150 | -0.073926503 | -0.043595752 | 0.0134402941 | -0.109703469 |
| Haarlemmermeer | -0.0629313152 | -0.010853527 | -0.111126645 | 0.095163312 | -0.0316022525 | -0.104646121 | 0.137933910 | 0.026363553 | -0.1282081093 | 0.113562937 |
| Zaanstad | -0.0377488490 | 0.091511935 | -0.046256061 | 0.032928847 | -0.0318372274 | -0.016987125 | -0.013382110 | 0.033415502 | -0.0300532151 | 0.012188844 |
| Alphen | -0.0750560932 | -0.097886980 | -0.038290891 | 0.105511511 | -0.0631180135 | -0.110161729 | 0.108325503 | 0.025486276 | -0.0822918529 | 0.032657918 |
| Delft | 0.0002843286 | -0.072832109 | 0.164563552 | -0.117932844 | -0.1021336745 | 0.053239891 | -0.103932437 | -0.066163923 | 0.0198474852 | -0.083762189 |
| Dordrecht | -0.0655387855 | -0.114401278 | 0.079557610 | 0.019648224 | -0.0001812750 | -0.018673709 | -0.024762214 | 0.082426402 | 0.0103164875 | -0.039069105 |
| sGravenhage | 0.2607650184 | 0.308514243 | 0.220573416 | -0.040212481 | -0.0331698244 | 0.123740072 | -0.095887710 | 0.034155104 | 0.1349652093 | -0.101609319 |
| Leiden | 0.0501570884 | 0.001315431 | 0.099703367 | -0.115638748 | -0.0805037117 | -0.009863945 | -0.136470609 | -0.113951829 | 0.2250132056 | -0.051248876 |
| Zoetermeer | -0.0179724387 | 0.234682025 | 0.014336341 | 0.016828989 | -0.0038757395 | -0.036894282 | 0.007648988 | 0.008699250 | -0.0394287828 | -0.009468962 |
| Breda | -0.0247901416 | 0.107184538 | -0.057475998 | 0.006114109 | 0.0373127922 | -0.024042474 | 0.042575555 | -0.042772900 | -0.0534418241 | 0.024883219 |
| Eindhoven | -0.0103557112 | 0.011027058 | -0.034467385 | -0.090658634 | 0.0175864702 | 0.028306840 | 0.004577290 | -0.043450642 | -0.0369258042 | -0.050128618 |
| sHertogenbosch | -0.0426583889 | -0.042705995 | -0.072608333 | 0.019484129 | 0.0931471818 | -0.015201271 | 0.069792134 | 0.051451563 | -0.0147446117 | 0.028800868 |
| Tilburg | -0.0951204962 | -0.164211340 | 0.070378062 | -0.025239539 | 0.0928253582 | 0.039719963 | 0.011459423 | 0.102470879 | -0.0763012176 | -0.086093808 |
| Maastricht | -0.0252288017 | 0.056370408 | -0.060886773 | -0.104385625 | -0.0498968976 | 0.048227970 | -0.060582691 | -0.014659094 | -0.0257371801 | -0.032975452 |
| Venlo | -0.0732232897 | -0.093433181 | -0.087866287 | 0.015256079 | 0.1141741607 | -0.008675101 | 0.063281837 | 0.123168752 | -0.1059197794 | 0.036183312 |
| Westland | -0.0706595628 | -0.053073501 | -0.045191492 | 0.096099957 | -0.1702461142 | -0.112571329 | 0.074995663 | 0.077749186 | -0.1366083012 | 0.032130218 |

Table C2: Correlation table for zero-inflated negative binomial regression model with dummies (1)

| | Groningen | Almere | Leeuwarden | Emmen | Deventer | Enschede | Zwolle | Apeldoorn | Arnhem | Ede |
|--------------------|---------------|-------------|-------------|-------------|---------------|--------------|--------------|-------------|---------------|--------------|
| sharedcars | -0.0027838039 | -0.03376021 | -0.07272006 | -0.05516653 | -0.0486332152 | -0.056736170 | -0.022184493 | -0.05673617 | -0.01176870 | -0.04700005 |
| population | 0.0436032469 | 0.16243076 | -0.07235950 | 0.01730758 | -0.0538539612 | 0.012418178 | -0.026384056 | 0.01177026 | 0.01626627 | -0.03393657 |
| population_density | -0.0033622774 | -0.06117951 | -0.06155541 | -0.15751898 | -0.0462701171 | -0.080791757 | -0.062673219 | -0.12282594 | -0.01047329 | -0.10491260 |
| household_size | -0.0808725788 | 0.08831308 | -0.07539123 | 0.05771725 | 0.0321613183 | 0.003977069 | 0.012597373 | 0.06904135 | -0.06806216 | 0.16090367 |
| unemployment_ben_p | 0.0001525033 | 0.11238377 | 0.10968142 | 0.05756566 | 0.0718294302 | -0.026863543 | 0.046197424 | -0.03115906 | 0.06159771 | -0.14081390 |
| low_income_p | 0.0688959636 | -0.03924438 | 0.05971930 | -0.02168759 | -0.0210227104 | 0.063894611 | 0.001802761 | -0.05672401 | 0.13932938 | -0.0830816 |
| household_vehicles | -0.0451085337 | -0.03925686 | -0.02070732 | 0.13593695 | 0.0230145546 | 0.049521485 | -0.037453652 | 0.09094046 | -0.04173157 | 0.11377911 |
| low_edu_p | -0.1437443940 | 0.04002081 | -0.03209491 | 0.09596848 | -0.0081888535 | 0.042770718 | -0.053246921 | 0.01611722 | 0.03190338 | 0.02782705 |
| PTAI | 0.0626789097 | -0.03007199 | 0.06697401 | -0.09948696 | 0.0008696698 | -0.087607546 | -0.007313669 | -0.05493904 | 0.01485643 | -0.09387680 |
| distance | 0.0539410011 | 0.04720091 | 0.07012853 | 0.14092643 | 0.0394610155 | 0.009050162 | 0.053860488 | 0.06898872 | -0.01361811 | 0.10382643 |
| Groningen | 1.0000000000 | -0.03029779 | -0.03830865 | -0.02741777 | -0.0338926362 | -0.035716444 | -0.035117810 | -0.03571644 | -0.03802821 | -0.03420257 |
| Almere | -0.0302977873 | 1.00000000 | -0.02866408 | -0.02051508 | -0.0253598360 | -0.026724482 | -0.026276560 | -0.02672448 | -0.024890259 | -0.032240980 |
| Leeuwarden | -0.0383086517 | -0.02866408 | 1.00000000 | -0.02593935 | -0.0320650850 | -0.033790549 | -0.033224195 | -0.03379055 | -0.0337905495 | -0.040525528 |
| Emmen | -0.0274177697 | -0.02051508 | -0.02593935 | 1.00000000 | -0.0229492053 | -0.024184132 | -0.023778789 | -0.02418413 | -0.02574946 | -0.02315907 |
| Deventer | -0.0338926362 | -0.02535984 | -0.03206509 | -0.02294921 | 1.0000000000 | -0.029895357 | -0.029394288 | -0.02989536 | -0.027843501 | -0.036066390 |
| Enschede | -0.0357164436 | -0.02672448 | -0.03379055 | -0.02418413 | -0.0298953565 | 1.0000000000 | -0.030976034 | -0.03150407 | -0.03354318 | -0.03016874 |
| Zwolle | -0.0351178099 | -0.02627656 | -0.03322420 | -0.02377879 | -0.0293942884 | -0.030976034 | 1.0000000000 | -0.03097603 | -0.03298098 | -0.02966309 |
| Apeldoorn | -0.0357164436 | -0.02672448 | -0.03379055 | -0.02418413 | -0.0298953565 | -0.031504065 | -0.030976034 | 1.00000000 | -0.03354318 | -0.03016874 |
| Arnhem | -0.0380282110 | -0.02845424 | -0.03597766 | -0.02574946 | -0.0318303507 | -0.033543184 | -0.032980975 | -0.03354318 | 1.00000000 | -0.03212143 |
| Ede | -0.0342025744 | -0.02559174 | -0.03235831 | -0.02315907 | -0.0286282186 | -0.030168741 | -0.029663091 | -0.03016874 | -0.03212143 | 1.00000000 |
| Nijmegen | -0.0274177697 | -0.02051508 | -0.02593935 | -0.01856498 | -0.0229492053 | -0.024184132 | -0.023778789 | -0.02418413 | -0.02574946 | -0.02315907 |
| Amersfoort | -0.0474664943 | -0.03551634 | -0.04490702 | -0.03214027 | -0.0397303770 | -0.041868321 | -0.041166577 | -0.04186832 | -0.04457827 | -0.04009370 |
| Utrecht | -0.0448324314 | -0.03354543 | -0.04241499 | -0.03035670 | -0.0375256152 | -0.039544918 | -0.038882116 | -0.03954492 | -0.04210449 | -0.03786878 |
| Alkmaar | -0.0332650607 | -0.02489026 | -0.03147135 | -0.02252426 | -0.0278435015 | -0.029341797 | -0.028850007 | -0.02934180 | -0.03124096 | -0.02809812 |
| Haarlem | -0.0430890726 | -0.03224098 | -0.04076563 | -0.02917625 | -0.0360663900 | -0.038007170 | -0.037370142 | -0.03800717 | -0.04046721 | -0.03639621 |
| Haarlemmermeer | -0.0368880873 | -0.02760115 | -0.03489902 | -0.02497747 | -0.0308760450 | -0.032537526 | -0.031992173 | -0.03253753 | -0.03464354 | -0.03115840 |
| Zaanstad | -0.0292483497 | -0.02188479 | -0.02767123 | -0.01980449 | -0.0244814363 | -0.025798815 | -0.025366408 | -0.02579881 | -0.02746866 | -0.02470531 |
| Alphen | -0.0394132422 | -0.02949058 | -0.03728801 | -0.02668729 | -0.0329896486 | -0.034764865 | -0.034182180 | -0.03476487 | -0.03701504 | -0.03329133 |
| Delft | -0.0357164436 | -0.02672448 | -0.03379055 | -0.02418413 | -0.0298953565 | -0.031504065 | -0.030976034 | -0.03150407 | -0.03354318 | -0.03016874 |
| Dordrecht | -0.0428352824 | -0.03205108 | -0.04052553 | -0.02900440 | -0.0358539627 | -0.037783312 | -0.037150036 | -0.03778331 | -0.04022886 | -0.03618184 |
| sGravenhage | -0.0469963569 | -0.03516457 | -0.04446223 | -0.03182193 | -0.0393368629 | -0.041453631 | -0.040758838 | -0.04145363 | -0.04413674 | -0.03969659 |
| Leiden | -0.0323033157 | -0.02417064 | -0.03056146 | -0.02187305 | -0.0270385022 | -0.028493480 | -0.028015908 | -0.02849348 | -0.03033774 | -0.02728576 |
| Zoetermeer | -0.0179355694 | -0.01342012 | -0.01696845 | -0.01214444 | -0.0150124197 | -0.015820258 | -0.015555099 | -0.01582026 | -0.01684423 | -0.01514970 |
| Breda | -0.0313150929 | -0.02343121 | -0.02962653 | -0.02120391 | -0.0262113405 | -0.027621807 | -0.027158846 | -0.02762181 | -0.02940964 | -0.02645104 |
| Eindhoven | -0.0433416360 | -0.03242996 | -0.04100458 | -0.02934726 | -0.0362777906 | -0.038229946 | -0.037589184 | -0.03822995 | -0.04070440 | -0.03660954 |
| sHertogenbosch | -0.0399557376 | -0.02989649 | -0.03780125 | -0.02705462 | -0.0334437278 | -0.035243379 | -0.034652674 | -0.03524338 | -0.03752453 | -0.03374956 |
| Tilburg | -0.0590599668 | -0.04419105 | -0.05587535 | -0.03999038 | -0.0494343385 | -0.052094465 | -0.051221324 | -0.05209447 | -0.05546631 | -0.04988640 |
| Maastricht | -0.0274177697 | -0.02051508 | -0.02593935 | -0.01856498 | -0.0229492053 | -0.024184132 | -0.023778789 | -0.02418413 | -0.02574946 | -0.02315907 |
| Venlo | -0.0380282110 | -0.02845424 | -0.03597766 | -0.02574946 | -0.0318303507 | -0.033543184 | -0.032980975 | -0.03354318 | -0.03571429 | -0.03212143 |
| Westland | -0.0351178099 | -0.02627656 | -0.03322420 | -0.02377879 | -0.0293942884 | -0.030976034 | -0.030456853 | -0.03097603 | -0.03298098 | -0.02966309 |

Table C3: Continuation of correlation table for zero-inflated negative binomial regression model with dummies (2)

| | Nijmegen | Amersfoort | Utrecht | Alkmaar | Haarlem | Haarlemmermeer | Zaanstad | Alphen | Delft | Dordrecht |
|--------------------|--------------|--------------|--------------|--------------|--------------|----------------|-------------|-------------|---------------|--------------|
| sharedcars | 0.064584375 | -0.01395991 | 0.55599851 | -0.042044101 | -0.004546943 | -0.06293132 | -0.03774885 | -0.07505609 | 0.0002843286 | -0.065538786 |
| population | 0.157488054 | -0.11739494 | 0.13179063 | -0.039237606 | -0.067315930 | -0.01085353 | 0.09151193 | -0.09788698 | -0.0728321088 | -0.114401278 |
| population_density | -0.026364262 | 0.04468679 | 0.16781880 | -0.030156805 | 0.210361021 | -0.11112665 | -0.04625606 | -0.03829089 | 0.1645635521 | 0.079557610 |
| household_size | -0.081479784 | 0.07338050 | -0.07730549 | 0.008051140 | 0.001613661 | 0.09516331 | 0.03292885 | 0.10551151 | -0.1179328440 | 0.019648224 |
| unemployment_ben_p | 0.006543465 | 0.01366743 | -0.05019603 | -0.050078303 | -0.023321635 | -0.03160225 | -0.03183723 | -0.06311801 | -0.1021336745 | -0.000181275 |
| low_income_p | 0.048401458 | -0.03768845 | 0.03303919 | -0.030857786 | -0.036713150 | -0.10464612 | -0.01698712 | -0.11016173 | 0.0532398911 | -0.018673709 |
| household_vehicles | -0.045734540 | -0.01701167 | -0.13170229 | 0.013823518 | -0.073926503 | 0.13793391 | -0.01338211 | 0.10832550 | -0.1039324372 | -0.024762214 |
| low_edu_p | -0.048237849 | -0.06838813 | -0.14783158 | 0.005690814 | -0.043595752 | 0.02636355 | 0.03341550 | 0.02548628 | -0.0661639231 | 0.082426402 |
| PTAI | -0.012633505 | 0.19034756 | 0.23833279 | -0.012343910 | 0.013440294 | -0.12820811 | -0.03005322 | -0.08229185 | 0.0198474852 | 0.010316487 |
| distance | -0.015143716 | -0.05576921 | -0.08510271 | 0.028444472 | -0.109703469 | 0.11356294 | 0.01218884 | 0.03265792 | -0.0837621886 | -0.039069105 |
| Groningen | -0.027417770 | -0.04746649 | -0.04483243 | -0.033265061 | -0.043089073 | -0.03688809 | -0.02924835 | -0.03941324 | -0.0357164436 | -0.042835282 |
| Almere | -0.02760115 | -0.02188479 | -0.02949058 | -0.024890259 | -0.032240980 | -0.02760115 | -0.02188479 | -0.02949058 | -0.0267244822 | -0.032051084 |
| Leeuwarden | -0.04446223 | -0.030561463 | -0.016968452 | -0.031471350 | -0.040765633 | -0.03489902 | -0.02767123 | -0.03728801 | -0.0337905495 | -0.040525528 |
| Emmen | -0.018564977 | -0.03214027 | -0.03035670 | -0.022524265 | -0.029176248 | -0.02497747 | -0.01980449 | -0.02668729 | -0.0241841323 | -0.029004403 |
| Deventer | -0.03087605 | -0.02448144 | -0.03298965 | -0.027843501 | -0.036066390 | -0.03087605 | -0.02448144 | -0.03298965 | -0.0298953565 | -0.035853963 |
| Enschede | -0.024184132 | -0.04186832 | -0.03954492 | -0.029341797 | -0.038007170 | -0.03253753 | -0.02579881 | -0.03476487 | -0.0315040650 | -0.037783312 |
| Zwolle | -0.023778789 | -0.04116658 | -0.03888212 | -0.028850007 | -0.037370142 | -0.03199217 | -0.02536641 | -0.03418218 | -0.0309760338 | -0.037150036 |
| Apeldoorn | -0.024184132 | -0.04186832 | -0.03954492 | -0.029341797 | -0.038007170 | -0.03253753 | -0.02579881 | -0.03476487 | -0.0315040650 | -0.037783312 |
| Arnhem | -0.025749464 | -0.04457827 | -0.04210449 | -0.031240962 | -0.040467206 | -0.03464354 | -0.02746866 | -0.03701504 | -0.0335431838 | -0.040228858 |
| Ede | -0.023159069 | -0.04009370 | -0.03786878 | -0.028098122 | -0.036396207 | -0.03115840 | -0.02470531 | -0.03329133 | -0.0301687407 | -0.036181837 |
| Nijmegen | 1.000000000 | -0.03214027 | -0.03035670 | -0.022524265 | -0.029176248 | -0.02497747 | -0.01980449 | -0.02668729 | -0.0241841323 | -0.029004403 |
| Amersfoort | -0.032140265 | 1.000000000 | -0.05255447 | -0.038994707 | -0.050510827 | -0.04324177 | -0.03428615 | -0.04620186 | -0.0418683209 | -0.050213324 |
| Utrecht | -0.030356702 | -0.05255447 | 1.000000000 | -0.036830769 | -0.047707825 | -0.04084215 | -0.03238350 | -0.04363798 | -0.0395449180 | -0.047426831 |
| Alkmaar | -0.022524265 | -0.03899471 | -0.03683077 | 1.000000000 | -0.035398564 | -0.03030433 | -0.02402812 | -0.03237879 | -0.0293417970 | -0.035190070 |
| Haarlem | -0.029176248 | -0.05051083 | -0.04770782 | -0.035398564 | 1.000000000 | -0.03925396 | -0.03112424 | -0.04194107 | -0.0380071700 | -0.045582586 |
| Haarlemmermeer | -0.024977470 | -0.04324177 | -0.04084215 | -0.030304326 | -0.039253959 | 1.000000000 | -0.02664512 | -0.03590529 | -0.0325375257 | -0.039022757 |
| Zaanstad | -0.019804490 | -0.03428615 | -0.03238350 | -0.024028124 | -0.031124235 | -0.02664512 | 1.000000000 | -0.02846910 | -0.0257988147 | -0.030940917 |
| Alphen | -0.026687289 | -0.04620186 | -0.04363798 | -0.032378793 | -0.041941068 | -0.03590529 | -0.02846910 | 1.000000000 | -0.0347648651 | -0.041694040 |
| Delft | -0.024184132 | -0.04186832 | -0.03954492 | -0.029341797 | -0.038007170 | -0.03253753 | -0.02579881 | -0.03476487 | 1.000000000 | -0.037783312 |
| Dordrecht | -0.029004403 | -0.05021332 | -0.04742683 | -0.035190070 | -0.045582586 | -0.03902276 | -0.03094092 | -0.04169404 | -0.0377833117 | 1.000000000 |
| sGravenhage | -0.031821928 | -0.05509111 | -0.05203393 | -0.038608479 | -0.050010537 | -0.04281348 | -0.03394656 | -0.04574425 | -0.0414536313 | -0.049715980 |
| Leiden | -0.021873053 | -0.03786731 | -0.03576593 | -0.026537842 | -0.034375136 | -0.02942818 | -0.02333343 | -0.03144267 | -0.0284934796 | -0.034172670 |
| Zoetermeer | -0.012144439 | -0.02102483 | -0.01985810 | -0.014734441 | -0.019085893 | -0.01633923 | -0.01295528 | -0.01745772 | -0.0158202578 | -0.018973479 |
| Breda | -0.021203913 | -0.03670887 | -0.03467178 | -0.025725996 | -0.033323532 | -0.02852791 | -0.02261962 | -0.03048078 | -0.0276218073 | -0.033127260 |
| Eindhoven | -0.029347263 | -0.05080689 | -0.04798746 | -0.035606050 | -0.046121415 | -0.03948404 | -0.03130667 | -0.04218690 | -0.0382299463 | -0.045849765 |
| sHertogenbosch | -0.027054621 | -0.04683780 | -0.04423863 | -0.032824465 | -0.042518357 | -0.03639950 | -0.02886095 | -0.03889121 | -0.0352433789 | -0.042267929 |
| Tilburg | -0.039990377 | -0.06923258 | -0.06539065 | -0.048518984 | -0.062847864 | -0.05380337 | -0.04266038 | -0.05748646 | -0.0520944653 | -0.062477697 |
| Maastricht | -0.018564977 | -0.03214027 | -0.03035670 | -0.022524265 | -0.029176248 | -0.02497747 | -0.01980449 | -0.02668729 | -0.0241841323 | -0.029004403 |
| Venlo | -0.025749464 | -0.04457827 | -0.04210449 | -0.031240962 | -0.040467206 | -0.03464354 | -0.02746866 | -0.03701504 | -0.0335431838 | -0.040228858 |
| Westland | -0.023778789 | -0.04116658 | -0.03888212 | -0.028850007 | -0.037370142 | -0.03199217 | -0.02536641 | -0.03418218 | -0.0309760338 | -0.037150036 |

Table C4: Continuation of correlation table for zero-inflated negative binomial regression model with dummies (3)

| | sGravenhage | Leiden | Zoetermeer | Breda | Eindhoven | sHertogenbosch | Tilburg | Maastricht | Venlo | Westland |
|--------------------|-------------|--------------|--------------|--------------|-------------|----------------|-------------|-------------|--------------|-------------|
| sharedcars | 0.26076502 | 0.050157088 | -0.017972439 | -0.024790142 | -0.01035571 | -0.04265839 | -0.09512050 | -0.02522880 | -0.073223290 | -0.07065956 |
| population | 0.30851424 | 0.001315431 | 0.234682025 | 0.107184538 | 0.01102706 | -0.04270600 | -0.16421134 | 0.05637041 | -0.093433181 | -0.05307350 |
| population_density | 0.22057342 | 0.099703367 | 0.014336341 | -0.057475998 | -0.03446739 | -0.07260833 | 0.07037806 | -0.06088677 | -0.087866287 | -0.04519149 |
| household_size | -0.04021248 | -0.115638748 | 0.016828989 | 0.006114109 | -0.09065863 | 0.01948413 | -0.02523954 | -0.10438562 | 0.015256079 | 0.09609996 |
| unemployment_ben_p | -0.03316982 | -0.080503712 | -0.003875740 | 0.037312792 | 0.01758647 | 0.09314718 | 0.09282536 | -0.04989690 | 0.114174161 | -0.17024611 |
| low_income_p | 0.12374007 | -0.009863945 | -0.036894282 | -0.024042474 | 0.02830684 | -0.01520127 | 0.03971996 | 0.04822797 | -0.008675101 | -0.11257133 |
| household_vehicles | -0.09588771 | -0.136470609 | 0.007648988 | 0.042575555 | 0.00457729 | 0.06979213 | 0.01145942 | -0.06058269 | 0.063281837 | 0.07499566 |
| low_edu_p | 0.03415510 | -0.113951829 | 0.008699250 | -0.042772900 | -0.04345064 | 0.05145156 | 0.10247088 | -0.01465909 | 0.123168752 | 0.07774919 |
| PTAI | 0.13496521 | 0.225013206 | -0.039428783 | -0.053441824 | -0.03692580 | -0.01474461 | -0.07630122 | -0.02573718 | -0.105919779 | -0.13660830 |
| distance | -0.10160932 | -0.051248876 | -0.009468962 | 0.024883219 | -0.05012862 | 0.02880087 | -0.08609381 | -0.03297545 | 0.036183312 | 0.03213022 |
| Groningen | -0.04699636 | -0.032303316 | -0.017935569 | -0.031315093 | -0.04334164 | -0.03995574 | -0.05905997 | -0.02741777 | -0.038028211 | -0.03511781 |
| Almere | -0.03516457 | -0.024170642 | -0.013420116 | -0.023431214 | -0.03242996 | -0.02989649 | -0.04419105 | -0.02051508 | -0.02845424 | -0.02627656 |
| Leeuwarden | -0.04446223 | -0.030561463 | -0.016968452 | -0.029626527 | -0.04100458 | -0.03780125 | -0.05587535 | -0.02593935 | -0.035977662 | -0.03322420 |
| Emmen | -0.03182193 | -0.021873053 | -0.012144439 | -0.021203913 | -0.02934726 | -0.02705462 | -0.03999038 | -0.01856498 | -0.025749464 | -0.02377879 |
| Deventer | -0.03933686 | -0.027038502 | -0.015012420 | -0.026211341 | -0.03627779 | -0.03344373 | -0.04943434 | -0.02294921 | -0.031830351 | -0.02939429 |
| Enschede | -0.04145363 | -0.028493480 | -0.015820258 | -0.027621807 | -0.03822995 | -0.03524338 | -0.05209447 | -0.02418413 | -0.033543184 | -0.03097603 |
| Zwolle | -0.04075884 | -0.028015908 | -0.015555099 | -0.027158846 | -0.03758918 | -0.03465267 | -0.05122132 | -0.02377879 | -0.032980975 | -0.03045685 |
| Apeldoorn | -0.04145363 | -0.028493480 | -0.015820258 | -0.027621807 | -0.03822995 | -0.03524338 | -0.05209447 | -0.02418413 | -0.033543184 | -0.03097603 |
| Arnhem | -0.04413674 | -0.030337737 | -0.016844233 | -0.029409645 | -0.04070440 | -0.03752453 | -0.05546631 | -0.02574946 | -0.035714286 | -0.03298098 |
| Ede | -0.03969659 | -0.027285761 | -0.015149704 | -0.026451036 | -0.03660954 | -0.03374956 | -0.04988640 | -0.02315907 | -0.032121430 | -0.02966309 |
| Nijmegen | -0.03182193 | -0.021873053 | -0.012144439 | -0.021203913 | -0.02934726 | -0.02705462 | -0.03999038 | -0.01856498 | -0.025749464 | -0.02377879 |
| Amersfoort | -0.05509111 | -0.037867308 | -0.021024831 | -0.036708872 | -0.05080689 | -0.04683780 | -0.06923258 | -0.03214027 | -0.044578272 | -0.04116658 |
| Utrecht | -0.05203393 | -0.035765934 | -0.019858098 | -0.034671783 | -0.04798746 | -0.04423863 | -0.06539065 | -0.03035670 | -0.042104486 | -0.03888212 |
| Alkmaar | -0.03860848 | -0.026537842 | -0.014734441 | -0.025725996 | -0.03560605 | -0.03282446 | -0.04851898 | -0.02252426 | -0.031240962 | -0.02885001 |
| Haarlem | -0.05001054 | -0.034375136 | -0.019085893 | -0.033323532 | -0.04612142 | -0.04251836 | -0.06284786 | -0.02917625 | -0.040467206 | -0.03737014 |
| Haarlemmermeer | -0.04281348 | -0.029428181 | -0.016339226 | -0.028527914 | -0.03948404 | -0.03639950 | -0.05380337 | -0.02497747 | -0.034643536 | -0.03199217 |
| Zaanstad | -0.03394656 | -0.023333433 | -0.012955277 | -0.022619617 | -0.03130667 | -0.02886095 | -0.04266038 | -0.01980449 | -0.027468658 | -0.02536641 |
| Alphen | -0.04574425 | -0.031442672 | -0.017457719 | -0.030480778 | -0.04218690 | -0.03889121 | -0.05748646 | -0.02668729 | -0.037015041 | -0.03418218 |
| Delft | -0.04145363 | -0.028493480 | -0.015820258 | -0.027621807 | -0.03822995 | -0.03524338 | -0.05209447 | -0.02418413 | -0.033543184 | -0.03097603 |
| Dordrecht | -0.04971598 | -0.034172670 | -0.018973479 | -0.033127260 | -0.04584976 | -0.04226793 | -0.06247770 | -0.02900440 | -0.040228858 | -0.03715004 |
| sGravenhage | 1.00000000 | -0.037492247 | -0.020816588 | -0.036345285 | -0.05030367 | -0.04637389 | -0.06854686 | -0.03182193 | -0.044136741 | -0.04075884 |
| Leiden | -0.03749225 | 1.00000000 | -0.014308445 | -0.024982217 | -0.03457662 | -0.03187546 | -0.04711622 | -0.02187305 | -0.030337737 | -0.02801591 |
| Zoetermeer | -0.02081659 | -0.014308445 | 1.00000000 | -0.013870721 | -0.01919776 | -0.01769801 | -0.02616005 | -0.01214444 | -0.016844233 | -0.01555510 |
| Breda | -0.03634528 | -0.024982217 | -0.013870721 | 1.00000000 | -0.03351886 | -0.03090032 | -0.04567484 | -0.02120391 | -0.029409645 | -0.02715885 |
| Eindhoven | -0.05030367 | -0.034576623 | -0.019197764 | -0.033518856 | 1.00000000 | -0.04276758 | -0.06321624 | -0.02934726 | -0.040704402 | -0.03758918 |
| sHertogenbosch | -0.04637389 | -0.031875458 | -0.017698013 | -0.030900324 | -0.04276758 | 1.00000000 | -0.05827772 | -0.02705462 | -0.037524527 | -0.03465267 |
| Tilburg | -0.06854686 | -0.047116224 | -0.026160049 | -0.045674845 | -0.06321624 | -0.05827772 | 1.00000000 | -0.03999038 | -0.055466310 | -0.05122132 |
| Maastricht | -0.03182193 | -0.021873053 | -0.012144439 | -0.021203913 | -0.02934726 | -0.02705462 | -0.03999038 | 1.00000000 | -0.025749464 | -0.02377879 |
| Venlo | -0.04413674 | -0.030337737 | -0.016844233 | -0.029409645 | -0.04070440 | -0.03752453 | -0.05546631 | -0.02574946 | 1.00000000 | -0.03298098 |
| Westland | -0.04075884 | -0.028015908 | -0.015555099 | -0.027158846 | -0.03758918 | -0.03465267 | -0.05122132 | -0.02377879 | -0.032980975 | 1.00000000 |

Table C5: Continuation of correlation table for zero-inflated negative binomial regression model with dummies (4)

Appendix D: Outlier data

| Name | Shared cars | Residuals | Population | Population density | Household size | Share unemployment benefits | Share low education | Private household vehicles | Share low income | PTAI | Distance |
|---|-------------|-----------|------------|--------------------|----------------|-----------------------------|---------------------|----------------------------|------------------|----------|----------|
| Utrecht, Lunetten-Zuid | 22 | 19.831 | 7125 | 3486 | 2 | 0.014035 | 15.85965 | 0.7 | 13.3 | 16.9711 | 0.625 |
| Utrecht, Oog in Al | 18 | 15.00973 | 4370 | 9911 | 2.8 | 0.01373 | 5.720824 | 0.8 | 1.3 | 27.75533 | 0.325 |
| Utrecht, Dichterswijk | 21 | 12.49371 | 5265 | 13175 | 1.9 | 0.013295 | 8.357075 | 0.5 | 5.2 | 64.16536 | 0.35 |
| Utrecht, Lombok-West | 22 | 11.87152 | 5115 | 18352 | 1.7 | 0.01173 | 12.51222 | 0.4 | 10.3 | 59.97339 | 0.25 |
| The Hague, Rond de Energiecentrale | 14 | 11.33408 | 6250 | 12535 | 1.8 | 0.0144 | 22.72 | 0.5 | 14.1 | 12.3259 | 0.325 |
| Utrecht, Rivierenwijk | 26 | 10.13836 | 9285 | 12998 | 1.9 | 0.014001 | 17.12439 | 0.6 | 8.5 | 71.81861 | 0.375 |
| Utrecht, Voordorp en Voorveldsepolder | 11 | 10.09715 | 4570 | 2518 | 2.1 | 0.015317 | 9.40919 | 0.8 | 4.7 | 8.699037 | 0.65 |
| Utrecht, Welgelegen, Den Hommel | 11 | 9.893832 | 1500 | 4178 | 1.6 | 0.013333 | 6.666667 | 0.5 | 5.2 | 34.25871 | 0.7 |
| Utrecht, Laan van Nieuw-Guinea, Spinozaweg e.o. | 15 | 8.774261 | 4255 | 14269 | 1.7 | 0.011751 | 10.10576 | 0.5 | 7.8 | 55.23992 | 0.35 |
| Utrecht, Transwijk-Noord | 10 | 8.505233 | 3995 | 4860 | 1.7 | 0.012516 | 19.02378 | 0.5 | 1 | 59.92421 | 0.55 |

Table D1: 10 neighbourhoods with largest positive residuals for zero-inflated negative binomial regression without municipality dummies

| Name | Shared cars | Residuals | Population | Population density | Household size | Share unemployment benefits | Share low education | Private household vehicles | Share low income | PTAI | Distance |
|--------------------------------|-------------|--------------|------------|--------------------|----------------|-----------------------------|---------------------|----------------------------|------------------|-------------|----------|
| Groningen, Binnenstad-Zuid | 7 | -75.0847 | 6565 | 11913 | 1.2 | 0.009139 | 5.483625 | 0.3 | 18.5 | 152.5073 | 0.375 |
| Leiden, d'Oude Morsch | 1 | -71.95756963 | 845 | 11418 | 1.4 | 0.01183432 | 3.5502959 | 0.3 | 14.4 | 272.42 | 0.675 |
| Groningen, Binnenstad-Oost | 2 | -23.784 | 3965 | 14781 | 1.3 | 0.010088 | 8.827238 | 0.2 | 18.3 | 129.9004 | 0.525 |
| The Hague, Huygenspark | 6 | -20.559 | 7870 | 17303 | 1.5 | 0.011436 | 19.94917 | 0.2 | 21.3 | 91.35415 | 0.35 |
| Amersfoort, Zonnehof | 0 | -20.1472657 | 215 | 3673 | 1.3 | 0 | 4.6511628 | 0.7 | 6.7 | 224.2336058 | 0.325 |
| Nijmegen, Stadscentrum | 9 | -19.2083 | 9090 | 9959 | 1.3 | 0.013201 | 7.150715 | 0.4 | 12.6 | 67.45317 | 0.475 |
| The Hague, Schildersbuurt-West | 5 | -18.5737 | 14220 | 22104 | 2.3 | 0.015471 | 41.56118 | 0.5 | 25.6 | 55.65832 | 0.3 |
| Leiden, Molenbuurt | 1 | -15.17651792 | 520 | 9498 | 1.3 | 0.019230769 | 5.7692308 | 0.2 | 10.7 | 200.9440623 | 0.6 |
| The Hague, Leyenburg | 11 | -12.8392 | 15010 | 11646 | 1.9 | 0.015989 | 21.2525 | 0.7 | 6.8 | 28.12491 | 0.45 |
| Groningen, Binnenstad-Noord | 3 | -10.5668 | 4400 | 11866 | 1.2 | 0.011364 | 7.5 | 0.2 | 15.7 | 79.45656 | 0.375 |

Table D2: 10 neighbourhoods with largest negative residuals for zero-inflated negative binomial regression without municipality dummies

Appendix E: Interview guides

Introduction of the research context

The centre of attention of this research is put on a societal problem which is sometimes referred to as transport-poverty. It basically refers to people in society that have a low income and for whom mobility can be more difficult. They often live in areas of cities where public transport is not as frequent and where they face longer distances to schools and supermarkets. These are the population groups that I am interested in in my study and there are some neighbourhoods in each municipality where these conditions can be observed. For my study I selected the following neighbourhoods in Utrecht/The Hague/Enschede:

Utrecht: Lunetten-Zuid, Zuilen-Noord, Transwijk-Zuid

The Hague: Rond de Energiecentrale, Venen, Oorden en Raden, Heesterbuurt

Enschede: De Bothoven, Getfert, Stevenfenne

We can discuss these neighbourhoods specifically, but you can also use them as an example for what kind of neighbourhoods I would like to talk about. My point of departure is that carsharing could at least theoretically really have an impact in these kinds of neighbourhoods, but it has not made a break-through there yet, so I would like to discuss what potential there is and how to use this potential.

Interview guide A: providers

1: Introductory questions

- 1.1 What is your role at (provider)?
- 1.2 What are the main goals (provider) is aiming to achieve?
- 1.3 Do you believe that carsharing can improve our society's sustainability? Both the environmental and social sustainability?
- 1.4 Is this a goal of (provider)?

2: Local performance of carsharing

- 2.1 How many municipalities across the Netherlands are you currently serving?
- 2.2 In these municipalities would you say that you are serving most neighbourhoods, or are you only serving specific ones?

If specific ones: Why do you think that is? What characteristics should a neighbourhood have to be supplied with shared cars?
- 2.3 Do you believe (provider) serves many neighbourhoods where the accessibility of public transport is low? And where distances to facilities such as schools are longer?

If no, why do you think that is?

- 2.4 Do you believe (provider) serves many neighbourhoods with a low average household income?
 If no, why do you think that is?
- 2.5 Did (provider) ever make any bad experiences in these neighbourhoods? Did (provider) ever have to pull back from a neighbourhood?
- 2.6 Do you believe carsharing could have a positive impact on these neighbourhoods I just described?
- 2.7 Is (provider) aiming for growth? Is (provider) generally planning to upscale and increase the area served in the future?
- 2.8 What areas do you think this expansion is currently focusing on or will focus on next?
- 2.9 Do you think that the final stage would be that all neighbourhoods within a municipality are served?
 If yes: Do you think these transport-poor neighbourhoods would be interesting targets for (provider) in the near future?
 If no: Do you think these transport-poor neighbourhoods will still be interesting?
- 2.10 You have carsharing vehicles in Utrecht, The Hague and Enschede. How would you say do these municipalities differ?

3: Opportunities for carsharing

- 3.1 Who do you think are the typical users of carsharing?
 What do you think the typical user needs carsharing for?
- 3.2 How do you think do people in transport-poor neighbourhoods differ from those in other neighbourhoods in their need for carsharing?
- 3.3 Does carsharing offer an advantage for low-income people?
- 3.4 Regarding the specific municipalities of Utrecht, The Hague and Enschede: can you see different opportunities?
- 3.5 Do you think there might be something in the context of over-achieving neighbourhoods that makes them successful?
 Does policy play a role? (can skip to policy part)

4: Barriers for carsharing

- 4.1 Is it easy to introduce people to the idea of carsharing?
- 4.2 What do you think are the reasons, valid or not, why people do not use carsharing?
 If answer is availability: Why do they decide not to use carsharing?

- 4.3 With regards to the low-income people, do you think there are different reasons?
- Can carsharing be easily integrated in the mobility habits of people?
 - Is price an issue?
 - Do many people not know how to drive a car?
 - Do many people not have smartphones to use the app?
 - Do people not have the basic understanding of how it works?
 - Do they need additional products like kids chairs which are not supplied?
 - Is culture/values a factor?
- 4.4 Do you think there are reasons that can be eliminated? ´
- 4.5 Regarding the specific municipalities of Utrecht, The Hague and Enschede. Do you find them to have different barriers?
- 4.6 Do you think there could be different barriers in place in under-achieving neighbourhoods?

5: Adaptations of carsharing offer

- 5.1 Is carsharing a service that can be adjusted to the needs of users well or is it quite rigid?
- 5.2 In what ways is (provider) currently adapting their offer to accommodate for the needs of users?
- 5.3 Do you think it would be a possibility that the offer can be adjusted in a transport-poor neighbourhood to better fit local needs?
- What do you think could be an adaptation which would make carsharing more interesting for transport-poor people?
 - Can specify more by repeating the barriers and opportunities mentioned earlier.
- 5.4 Can you think of collaborations that can be beneficial? For example, with municipalities or social housing associations?
- Do you have any collaborations?
 - If no, why do you not?
 - Do you know of any collaborations? Maybe to reduce parking?

6: Policy intervention

- 6.1 Do you know about any policies that have been introduced that support carsharing? This could be subsidies, restrictions on parking etc.
- 6.2 Is the parking policy introduced by municipalities important for carsharing?
- Is non-availability of parking spaces for shared cars an issue that policy can help?

- 6.3 What do you think of the effect of policy on carsharing success?
- 6.4 Do you believe that this could support the availability and uptake of carsharing in transport-poor neighbourhoods?
 - As far as you know is there anything in place concerning that?
- 6.5 Regarding the specific municipalities of Utrecht, The Hague and Enschede: is policy an underlying reason for the differences?

7: Last question

- 7.1 Is there anything that you would like to add?
- 7.2. Would you like your personal details/company details made anonymous in the research?
- 7.3 Do you know anyone that you think could add interesting insights to this research?

Interview guide B: municipalities

1: Introductory questions

- 1.1 What is your role at the municipality?
- 1.2 Have you been dealing with carsharing as part of this role?
- 1.3 Do you believe that carsharing can improve our society's sustainability? Both the environmental and social sustainability?
- 1.4 How would you describe the three sample neighbourhoods? Do you see how they fit the description I provided earlier?

2: Local performance of carsharing

- 2.1 How would you describe the performance/availability of carsharing in your municipality?
- 2.2 How does this compare to other municipalities in the Netherlands? What are reasons for this?
- 2.3 Is carsharing serving specific neighbourhoods in your municipality?
 - If yes: Why do you think that is? What characterises the neighbourhoods that are supplied with shared cars?
- 2.4 Do you believe that the neighbourhoods that have less public transport accessibility and longer distances from facilities such as schools get more or less supply?
 - Same question for neighbourhoods with more low-income people?
- 2.5 Do you believe carsharing could have a positive impact on these neighbourhoods?

- 2.6 With regards to the neighbourhoods, I mentioned earlier, do you know what the carsharing situation is like there?

3: Opportunities for carsharing

- 3.1 How do you think do people in transport-poor neighbourhoods differ from those in other neighbourhoods in their need for carsharing?
- 3.2 Regarding the specific neighbourhoods, where do you see opportunities for carsharing?
- 3.3 What are people's mobility habits in these neighbourhoods like?
- How do they get around?
 - What trips to they take?
 - Do they travel far?
- 3.4 What advantage can carsharing offer to them?
- 3.5 Particularly, can carsharing be interesting for people living in social housing?
- 3.6 Do you think there are different circumstances in place in the over-achieving neighbourhood that benefit carsharing?
- Why do you think is (overperforming neighbourhood) supplied with so many more shared cars?

4: Barriers for carsharing

- 4.1 What do you think are the reasons, valid or not, why people do not use carsharing?
- If availability, why do they decide not to use carsharing?
- 4.2 With regards to the transport-poor people, do you think there are different reasons?
- Can carsharing be easily integrated in the mobility habits of people?
 - Is price an issue?
 - Do many people not know how to drive a car?
 - Do many people not have smartphones to use the app?
 - Do people not have the basic understanding of how it works?
 - Is there an understanding of what carsharing is and how to use it in the community?
 - Do they need add-ons like kids chairs which are not supplied?
 - Is culture/values a factor?
- 4.3 Do you think there are reasons that can be eliminated?
- 4.4 Regarding the specific neighbourhoods mentioned: do you think there would be different barriers?

Do you think there are additional barriers in the under-performing neighbourhood?

5: Adaptations of carsharing offer

5.1 Do you think the carsharing offer is the same in all of the neighbourhoods? Have you seen instances where the carsharing offer has been adapted for the local population?

5.2 Do you think it would be a possibility that the offer can be adjusted in a transport-poor neighbourhood to better fit local needs?

What adaptations would be good?

Can specify more by repeating the barriers and opportunities mentioned earlier

5.3 Are there currently any collaborations between your municipality and carsharing providers?

5.4 Do you know about other collaborations they might have in your municipality? For example with social housing associations?

5.5 Have you heard of any other collaboration somewhere else that you thought were interesting?

6: Policy intervention

6.1 Can you think of actions that can be taken on the policy level that will support carsharing? Directly and indirectly.

In your municipality are there any policies like that?

6.2 Do you believe that policy could support the availability and uptake of carsharing in transport-poor neighbourhoods and with people living in social housing?

Are there any specific policies in place?

6.3 What is your parking policy like?

6.4 What other policies do you know from other municipalities that could be interesting?

6.5 Regarding the specific municipalities of Utrecht, The Hague and Enschede: is policy an underlying reason for the differences?

7: Last question

7.1 Is there anything that you would like to add?

7.2 Would you like your personal details/company details made anonymous in the research?

7.3 Do you know anyone that you think could add interesting insights to this research?

Interview guide C: social housing associations

1: Introductory questions

- 1.1 Which municipalities is (association) active in?
- 1.2 What service does (association) provide?
- 1.3 What is your role within (association)?
 - Have you been dealing with carsharing as part of this role?
- 1.4 Do you believe that carsharing can improve our society's sustainability? Environmental and social?
- 1.5 Is (association) active in all of the three sample neighbourhoods?
 - How would you describe them?
 - Do you see how they fit the characteristics I described earlier?
- 1.6 Overall, would you say many of your residents live in neighbourhoods with insufficient public transport accessibility and long distances?

2: Local performance of carsharing

- 2.1 In the neighbourhoods you are active in how is the carsharing supply?
 - Especially focusing on the three sample neighbourhoods?
- 2.2 How does it compare to carsharing supply in other neighbourhoods?
- 2.3 If there is supply, is this supply used by your residents?

3: Opportunities for carsharing

- 3.1 What do the mobility habits of your residents look like? What are their trips like?
 - What means of transport do they use? Public transport, private car, do they use carsharing already, do they mainly walk, or bike?
 - Do they travel a lot and for long distances? Or do they stay quite local?
 - How do people get to the supermarket, the doctor, the school, to work?
 - Are people limited in their mobility?
 - Do people perceive their mobility as a financial burden?
- 3.2 Can carsharing offer an advantage for people in social housing?
- 3.3 How do you think do people living in social housing differ from others in their need for carsharing?
- 3.4 What trips could they replace with carsharing as the means of transport?

- 3.5 Would this mean a large change in their habits? Can they just change one day to the other or is it a process?
- 3.6 Regarding the specific neighbourhoods, where do you see opportunities for carsharing?
Do you think the under-performing neighbourhood could still be a place where carsharing could thrive?

4: Barriers for carsharing

- 4.1 What do you think are the reasons, valid or not, why people do not use carsharing?
If availability, why do they decide not to use carsharing?
- 4.2 With regards to the people living in your housing, do you think there are different reasons?
Can carsharing be easily integrated in the mobility habits of people?
Is price an issue?
Do many people not know how to drive a car?
Do many people not have smartphones to use the app?
Do people not have the basic understanding of how it works?
Is there an understanding of what carsharing is and how to use it in the community?
Do they need add-ons like kids chairs which are not supplied?
Is culture/values a factor?
- 4.3 Do you think there are barriers that can be eliminated?
- 4.4 Regarding the specific neighbourhoods mentioned: do you think there would be different barriers?
Do you think there are specific barriers in place in the under-achieving neighbourhood?

5: Adaptations of carsharing offer

- 5.1 What do you think could be an adaptation which would make carsharing more interesting for people living in social housing?
Can specify more by repeating the barriers and opportunities mentioned earlier.
- 5.2 Are there currently any collaborations between social housing associations and carsharing providers that you know about? Or with municipalities to improve carsharing?
If yes, how were the experiences from that?
If no, why was there no collaboration yet?
- 5.3 Would (association) consider a collaboration with a carsharing provider?

- 5.3 Apart from direct collaborations do you think there are things (association) could do to make carsharing more accessibly for residents?

How about your parking policy?

6: Policy intervention

- 6.1 Do you believe that policy could support the availability and uptake of carsharing in these neighbourhoods and especially with the residents of social housing?

What policy actions could this be? E.g. subsidies, limitations on parking spaces for cars etc.

- 6.2 In your municipality are there any policies like that which you know of?

- 6.3 Do you know of anything done in other municipalities that is interesting?

- 6.4 Could policies support the under-performing neighbourhoods?

7: Last question

- 7.1 Is there anything that you would like to add?

- 7.2. Would you like your personal details/company details made anonymous in the research?

- 7.3 Do you know anyone that you think could add interesting insights to this research?