Carsharing, a solution for transport poverty

A research on the B2C carsharing market in the four largest cities in the Netherlands

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Abstract

Recently carsharing has become perceived as an option to make cities more livable. Carsharing is a new mobility option benefitting users in different ways. Carsharing can offer a solution for individuals at risk of not being able to reach destinations, which hinders participation in society, also known as transport poverty. However, previous studies have shown that carsharing is being embraced by people who are already mobile. This study investigates how shared cars are distributed across Amsterdam, Rotterdam, The Hague and Utrecht and how this distribution is related to demographic factors. This study also tests how mobility policy is related to the link between shared mobility and transport poverty. The study is done on the basis of CBS data at neighbourhood level and the number of shared cars offered by platforms. By linking these different data, it became clear what the relationship is between demographic and geographical variables on the one hand and the number of shared cars on the other.

This study concludes that the number of shared cars in Amsterdam, Rotterdam, The Hague and Utrecht is related to the income of a neighbourhood. People in neighbourhoods with a higher income and employment rate have more shared cars at their disposal. This means that people with an increased risk of transport poverty have fewer shared cars at their disposal. And although Rotterdam and The Hague indicate that they want to use shared mobility against transport poverty, these two cities do not differ in their distribution compared to Amsterdam and Utrecht.

1. Introduction

1.1 Outline of the problem

The United Nations predicted in 2018 that 68% of the world's population would live in cities by 2050, compared to 55% in 2018 (Elmjid, 2018). Taking into account that the world population is growing, the UN states in Sustainable Development Goal (SDG) nr. 11; "*Make cities and human settlements inclusive, safe, resilient and sustainable*". Carsharing contributes to making cities more sustainable. The Netherlands committed to the SDG's and supports sustainable developments such as carsharing, which concretely led to the Green Deal CarSharing (Autodelen) I & II. In these deals, municipalities agree with providers on how to grow carsharing in the Netherlands, as an alternative for the private car. Carsharing is considered an additional answer to limited and expensive parking space and high fuel costs (Shaheen & Cohen, 2007). Furthermore, the use of shared cars is considered as having positive financial consequences for the user (Botsman & Rogers, 2010).

An important condition for an inclusive city (part of SDG#11) is furthermore the accessibility of destinations. This means that inhabitants can choose and reach different types of transport (heavy rail, light rail, buses, active transport and cars), and that these modes give access to a range of services, jobs and other destinations (Verzosa & Legacy, 2020). The shared car is one of the options that an individual can choose from to be mobile and reach locations.

In practice, however, it appears that not everyone uses the shared car equally. Shared cars are mainly used by men between 25 and 45 years who live in an urban environment, earn above average, are highly educated, live in a household without children (Kopp et al., 2015; Le Vine et al., 2014) and work fulltime (Kawgan-Kagan, 2015). People with a low income make less use of shared mobility (Kodransky & Lewenstein, 2014; Kim, 2015), as they have a low accessibility to shared mobility. This is largely because bike and car-share systems are rarely placed within a walkable or otherwise reasonably accessible distance from the places where most low-income individuals live (Bergman, 2013). While shared mobility can offer a solution for people who are unable to be mobile due to their socio-economic position (Currie, 2011).

This study investigated whether the findings of Bergman (2013), Kodransky & Lewenstein (2014) and Kim (2015) regarding limited accessibility for low-income groups still apply in 2021 to the four largest Dutch cities. This study investigated if there are differences among these four cities and if there has been a role by the local authorities in each city. This study used a quantitative approach to analyse whether the distribution of shared cars per city is related to demographic characteristics such as income, work, migration background, age and car ownership. The results of the quantitative analysis per city were compared to the policy approaches towards carsharing in the four cities.

1.2. Existing research

1.2.1 Mobility as a Service and Shared Mobility

1.2.1.1 Mobility as a Service

Carsharing has become part of a new concept, Mobility as a Service (MaaS).This concept relies on a digital platform that integrates end-to-end trip planning, booking, electronic ticketing, and payment services across all modes of transportation, public or private (Goodall et al., 2017). Travellers are presented a variety of travel options tailored to their respective needs, either as a subscription package or in a pay-per-use approach, by an integrated mobility provider (Kamargianni et al., 2016; Mulley, 2017).

1.2.1.2 Shared Mobility

Shared mobility can be defined as trip alternatives that aim to maximize the utilization of the mobility resources that a society can pragmatically afford, disconnecting their usage from ownership (Machado et al, 2018). Shared mobility includes different modes of carsharing, personal vehicle sharing, bike sharing, scooter sharing, traditional ridesharing, transportation network companies (or ridesourcing), and e-Hail (taxis). It can also include flexible transit services, including microtransit, which supplement fixed-route bus and rail services (Shaheen & Chan, 2016). These transport options can be divided into traditional and modern forms. The traditional forms of shared mobility are taxis, rental cars and public transport (Sprei, 2018). The modern forms of shared mobility include an element of sharing an asset (a vehicle) instead of owning it, and an element that they rely on technology (i.e., a digital platform) (Santos, 2018).

The popularity of carsharing is visible worldwide due to the enormous increased number of shared cars and users in the last ten years. Whereas in 2006, 0.35 million people used a shared car, in October 2018, 32 million users worldwide used almost 200,000 shared cars (Shaheen et al., 2018). The enormous growth has become possible partly due to the developments in the field of ICT. (Circella, 2017). The popularity of carsharing is due to environmental and social benefits (Brimont et al, 2016).

Carsharing has a positive effect on the environment in various ways. The air quality improved, because people can drive newer and cleaner cars (Nijland & Meerkerk, 2017) and because carsharing makes people consciously drive less (Migliore et al, 2020), which makes the living environment healthier (Kent, 2014). There are also fewer cars needed, which frees up space for greenery or recreation in the public space (Chen & Kockelman, 2016; Skinner & Bidwell, 2016).

There are also advantages for the user. Users do not have the risks associated with car ownership (Botsman & Rogers, 2010) and carsharing offers an economic advantage, to a greater extent for people who would otherwise not be able to purchase a car (Litman, 2000). In addition, there is more interaction between individuals who use carsharing, and there is more social cohesion (Lane, 2005).

2.2 The market of carsharing

Within the market of carsharing there are different constructions for how the shared car is offered. There are shared cars that are offered with a fixed location, one-way carsharing or free floating. At a fixed location, the car must be returned to the same place after use. One-way carsharing gives users the possibility to leave the car in a different place than where it was picked up. Free floating systems gives users the possibility to park the car at any free parking space within a certain area (Firnkorn & Müller, 2015; Wielinski et al., 2015).

A distinction can also be made between providers, namely business-to-consumer (B2C) and peer-to-peer (P2P). With B2C, an organization is the owner of the shared cars and makes the cars available in the public environment. In P2P an individual rents a car from another person who makes his car available. P2P carsharing has increased sharply around 2010 due to the online possibilities of carsharing platforms (Frenken & Schor, 2019).

1.2.3 Users of carsharing

Research shows that the main people that make use of shared cars are young adults with higher education (Burkhardt & Millard-Ball, 2006; Efthymiou et al., 2013) who live alone or in small households without children in predominantly urban areas (Le Vine et al., 2014) and who are more likely to be full-time employed (Kawgan-Kagan, 2015) and have a higher income (Efthymiou et al., 2013; Kawgan-Kagan, 2015). Shared mobility is also used significantly more by users who are associated with the university as a student, professor or employee (Zheng et al., 2009), and cities where more people vote for green politics. (Münzel et al., 2017) Carsharing is adopted by what Rogers' (2003) calls the early adopters in his theory on the diffusion on innovation. The early adopters are characterized by the availability of sufficient financial resources and the search for new innovations. There are also groups that make significantly less use of carsharing, because they live at a greater distance from the carsharing opportunities and have financial constraints (Bergman, 2013). These are especially people with a low income and people of colour. These people less often have a driver's license and experience more digital barriers (Kodransky & Lewenstein, 2014; Kim, 2015).

1.2.4 The adoption of carsharing and the role of governments

For urban policymakers, carsharing offers an opportunity to make cities more sustainable and liveable. Zhou et al., (2020) see policymakers as a driving force to get more people to switch to carsharing by creating more awareness among residents. However, this requires good cooperation between local governments and providers of shared mobility (Kent & Dowling, 2016). Tuominen et al., (2019) argue that public authorities have an important role in the provision of shared mobility due to the incredibly dynamic market, an increase in carsharing can lead to a decrease in publicly funded public transport, carsharing can lead to social exclusion of groups in society (because only a specific target group makes use of carsharing), and carsharing requires spatial planning and thus interaction between companies and municipalities. Turoń & Sierpiński (2019) furthermore note that it is important that governments do not see carsharing as a threat to public transport, but as an addition that can be used to prevent social exclusion.

1.2.5 Carsharing and transport poverty in the Netherlands

1.2.5.1 Carsharing

In the Netherlands, various government levels are working on a mobility shift in which carsharing plays an important role. At the national level, the Green Deal Autodelen I & II are agreements to make the field of mobility more sustainable. This consists of collaborations between the national government, municipalities, companies and citizens with the aim to increase the number of shared cars to 100,000 by the end of 2021 and the number of users to 700,000 (Green Deal Autodelen II, 2018). In October 2020, a year before the project deadline, it became clear that this target has been achieved (CROW, 2020). Partly due to partnerships such as the Green Deal Autodelen, the number of shared cars in the Netherlands increased between 2012 and 2020 from 2,643 to 64312. The National Smart Mobility Monitor (Newcom Research & Consultancy, 2020) shows that the characteristics of the users of shared cars in the Netherlands correspond with the international shared car users. These characteristics are young age, higher educated, employed and environmentally aware.

1.2.5.2 Transport poverty

Several studies have indicated that carsharing can reduce transport poverty (Currie, 2011; Brimont et al, 2016; Shaheen et al., 2016). The concept of transport poverty consists of three different components (Lucas et al., 2016), namely a systematic lack of access to transport options, the difficulty of achieving certain core activities such as work, education and health care and the lack of individual financial resources. In addition, people's personal circumstances can play a role, such as health and knowledge (CBS & PBL, 2019).

In the Netherlands, following a motion submitted by Member of Parliament Suzanne Kröger (23 April 2019) and research by Statistics Netherlands (hereafter CBS) & the Netherlands Environmental Assessment Agency (2019), more attention has been paid to transport poverty. Although there are no clear figures of the extent of transport poverty in the Netherlands, there is a number of characteristics that are predictors of transport poverty (Jorritsma et al., 2018). The predictors are having no or a low income (Clifton & Lucas, 2004), having a migration background (Harms, 2006), not having a driving license (Holder, 2010), unemployment (Bastiaanssen, 2012;

Bastiaanssen et al., 2013), being elderly (Jorritsma & Olde Kalter, 2008) and having a disability (Thijssen, 2010). Jorritsma et al (2018) stated in their study for KiM that in the Netherlands these risk groups are mainly centred in the periphery of the big cities and in the rural areas.

1.2.6 Carsharing policies in the G4

The four largest cities in the Netherlands, Amsterdam, Rotterdam, The Hague and Utrecht (G4), are currently promoting carsharing. These four cities are all in the top 4 of the increase in the absolute number of shared cars between 2019 and 2020 from all Dutch cities.

Amsterdam states in the *Agenda Autodelen* (2019) that it wants to encourage carsharing because it reduces the pressure on the city (less private cars) and provides space for cyclists and pedestrians. The positive effects on the air quality are also a reason for the municipality to encourage carsharing. In addition, the municipality itself aspires to only have fully emission-free (electric) shared cars in the city in a number of years.

Rotterdam also bases its policy of promoting carsharing on the positive effects for space and the environment. In the *Nota Beleid en Vergunningen Deelauto's* (2020), the municipality links carsharing to other policy goals, such as guaranteeing the mobility of all residents. Rotterdam mentions that shared cars contribute to the enrichment of mobility choices and reduce transport poverty.

The Hague, like Rotterdam, mentions that transport poverty can be partly reduced by the use of shared mobility. But in order to deploy the solution that offers shared mobility, the different shared modalities must be available to everyone. In addition, paying according to use must also make the environmentally friendly and expensive modalities affordable for everyone (Regulering Deelmobiliteit Fiets Den Haag, 2019).

Utrecht stated in its plans for the period of 2015 to 2020 that carsharing had to grow, as they assume that the growth of carsharing would result in a smaller number of private cars in the city, which would lead to a cleaner city and a more conscious use of cars. Utrecht has promoted the use of shared cars by increasing knowledge, providing information and subsidies (*Actieplan Schoon Vervoer,* 2015). Governments have the power to use shared mobility as a tool/strategy against transport poverty (Shaheen et al., 2016; Jansen., 2017; Tuominen et al., 2019). The policy documents of Rotterdam and The Hague show that they recognize this link and want to act on these possibilities. However, research by Nijhof (2020) shows that Rotterdam, The Hague and Utrecht do not use specific policy instruments related to carsharing to target specific areas with a less developed mobility network.

1.2.7 Research gap

Carsharing is growing in the four largest cities in the Netherlands. In the policy documents, local governments recognize the spatial and environmental opportunities of carsharing. However, it remains unclear whether the neighbourhoods where transport poverty can occur more often benefit from the growth of carsharing or whether shared cars only benefit people who are at less risk of transport poverty. This study aims to provide more insight into whether the social promise made in the literature is also feasible through growth alone or whether government policy is necessary to prevent social inequality within shared mobility.

1.3. Theoretical framework

The theoretical framework used in this study distinguishes the different dimensions that influence the individual capability to use a shared car. These dimensions are determined by the demographic background of the user, by the market strategy of the provider and the policy of the municipality. The framework is shown in figure 3.

1.3.1 Carsharing providers

For many providers in the carsharing market who recently entered the market becoming profitable is a difficult task (Empaction, 2021). To become profitable, providers follow the strategy of expansion, with the idea that a large fleet will develop into a large number of users. Also, with a larger volume, the high costs incurred for the hardware (vehicles and charging stations) and software (platform and keyless entry) can be regained. To guarantee that a large number of users also make use of the carsharing offer, strategic car placement of the shared cars is essential. Providers can do strategic placement by segmenting in two ways by geographic and demographic (Figure 1). Geographic looks at characteristics of the environment, such as parking pressure (high prices and low availability), the possibility to live without a car (people can travel with alternatives), density of an area (high population density brings a large customer base within a walking distance of each carsharing location) and mixed use of the cars (business uses during the workday and residential uses in the evenings and on weekends) (Celsor & Millard-Ball, 2007). These variables are more common in cities where more users live close to each other and where life without a car is easier than outside the city, due to the proximity of amenities and alternatives for mobility. In demographic segmentation, the provider targets towards areas where the most frequent users live, mainly young, highly educated men with a higher income.

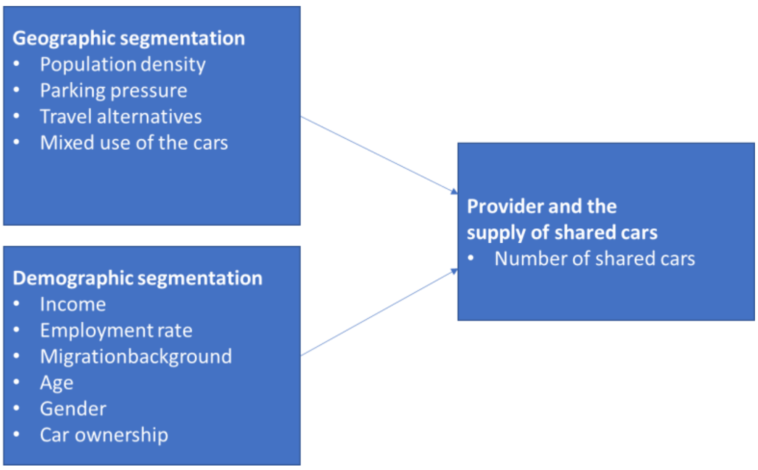

Figure 1; Two ways of segmentation

1.3.2 The capability approach

Sen (1995) states in his capability approach that being able to use a service or taking an action depends on the capability set. This set is made up of different functionings, which can be income, but also health and the skills to process information. The capability set and associated functionings are determined by commodities, personal environment, characteristics and resources.

Denmark (1998) uses the capability approach to indicate that a weaker capability set, may result in a disadvantage in urban transportation. Denmark distinguishes three different functionings that can influence the capability set in urban mobility of a person: (a) personal mobility and social economic characteristics (e.g. age, gender, income), (b) area accessibility created by the physical environment where an individual lives (c) resource availability and public transport service levels (e.g. route, linkage and temporal) .

Building on the work of Sen (1995) and Denmark (1998), Rashid et al, (2010) distinguish three different dimensions; the socio-economic dimension, the spatial dimension and the public transportation dimension.

Sen (1995)		Denmark (1998)	Rashid et al, (2010)
Capabiltiy set	Functioning a	Personal mobility and social economic characteristics	Socio-economic dimension
	Functioning b	Area accessibility created by the physical environment where an individual lives	Spatial (geographic) dimension
	Functioning c	Resource availability and public transport service levels	The public transportation / service dimension

Figure 2; Elaboration of the capability approach

Rashid et al, (2010) state that the combination of the dimensions allows to identify individual transport disadvantage. For each dimension they mention a number of variables that underlie urban transportation disadvantage. The model created by Rashid et al, (2010) is also applicable to carsharing. The relationship between the demographic, spatial (hereafter geographic) and service dimension in the field of shared cars makes whether the shared car is an extra option to be mobile, or whether shared cars are not available to everyone and thus relatively increase the transport disadvantage for certain groups. The relationships between the dimensions, the possibility of using a shared car and transport poverty are shown in figure 3.

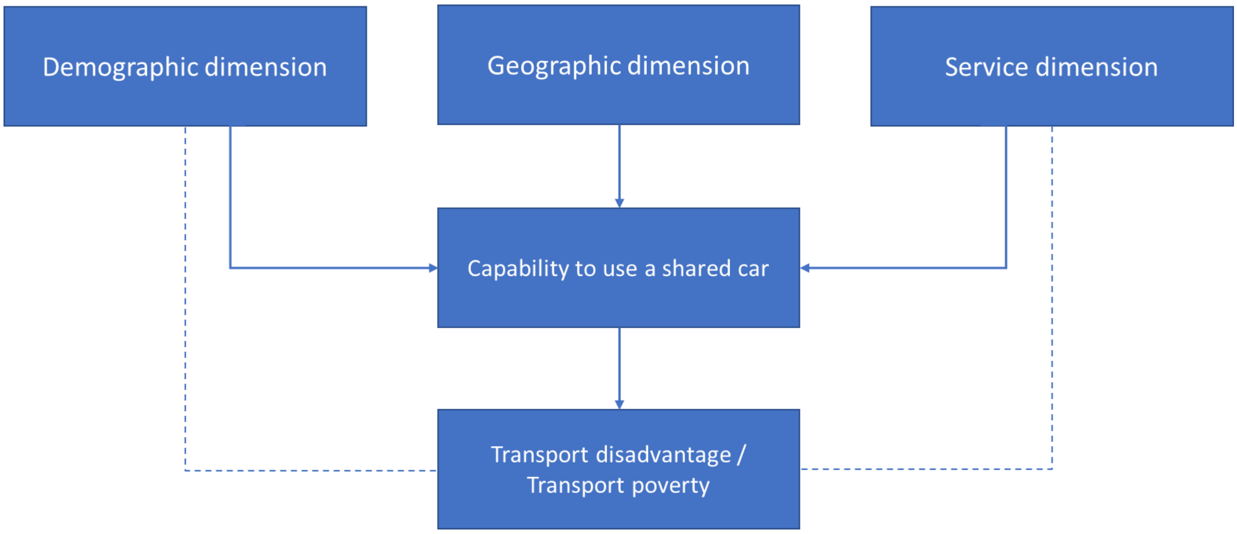

Figure 3; Three dimensions for the use of a shared car (inspired by Sen 1995, Denmark 1998, Rashid et al, 2010).

The demographic dimension that influences the ability to use a shared car consists of income (Clifton & Lucas, 2004), a migration background (Harms, 2006), not having a driving license (Holder, 2010), unemployment (Bastiaanssen, 2012; Bastiaanssen et al., 2013), age (Jorritsma & Olde Kalter, 2008) or having a disability (Thijssen, 2010). These demographic characteristics also have a direct relationship with transport poverty (Jorritsma, 2018).

The geographic dimension determines the accessibility of modalities and thus influences the possibility of using a shared car. For carsharing, this is determined by the extent to which a shared car can be reached within walking distance (De Luca & Di Pace, 2015). The geographic features are therefore the features of the living environment.

Finally, the service dimension influences the possibility of using a shared car. This is because there will have to be a supply of shared mobility that meets the need (Paundra et al., 2017). The amount of available modalities, of which the shared car is an option, has a direct influence on the likelihood of transport poverty (Lucas et al., 2016).

1.3.3 The role of the provider and the local government

By placing their supply, the providers of shared mobility determine on the basis of distance for whom shared cars are relatively easily accessible because the cars are within an acceptable distance. With the offer, providers partly determine the geographic and service dimension, and thus indirectly influence the risk of transport poverty. The government has the possibility of using policy and instruments to steer the supply of shared mobility (Tuominen et al., 2019). This can affect the geographic and service dimension.

1.4 Hypotheses & research question

1.4.1 Hypotheses

The application of the capability approach to transport poverty shows three dimensions that determine whether someone can use a shared car. An important condition for use is that a shared car is available to the individual's proximity. Demographic backgrounds should not influence the presence of shared cars. On the one hand, the literature shows that the users have the same characteristics, namely young, highly educated and with an above-average income (Burkhardt & Millard-Ball, 2006; Efthymiou et al., 2013; Le Vine et al., 2014; Kawgan-Kagan, 2015). These characteristics correspond to those of the early adopter (Rogers, 2003). On the other hand, providers have the difficulty to become profitable, which means that they have to segment demographically. This means that the demographic background is strongly related to the geographic and service dimension. Therefore hypothesis 1 states:

1a: In neighbourhoods where the characteristics of the early adopter are more present, the supply of shared cars will be higher.

On the other hand, people with a lower socio-economic status are less interesting for providers. People with a lower income, a migration background or without a driver's license already make less use of shared cars (Kodransky & Lewenstein, 2014; Kim, 2015). This means that people who score less on the capability set also have fewer opportunities to make use of shared mobility. Because the low income, migration background and no driver's license are mentioned in relation to transport poverty, just like unemployment, older age and having a disability, the expectation is that these people will also make less use of shared mobility. Which means that people of low socio-economic status that experience transport poverty are not an interesting target group for providers. Therefore hypothesis 1b states:

1b: In neighbourhoods where the characteristics of low socio-economic status and transport poverty are more present, fewer shared cars will be made available by providers of carsharing.

Another way of segmenting that providers can use is geographic segmentation, which looks at the degree of urbanity. In areas where more people live together, where parking is more expensive and more difficult and where shared mobility can link up with other modalities, the chance of success of shared mobility is greater (Celsor & Millard-Ball, 2007). This means that the geographical dimension, the distance to a car and urban characteristics, are strongly related to the service dimension, the number of available shared cars. Based on the geographic segmentation, hypothesis 2 states:

2. *In urban areas where characteristics such as density and parking pressure are more present, more shared cars are made available by carsharing providers.*

Nijhof (2020) discovered that few or no specific policy instruments are used to link shared mobility to transport poverty. Nevertheless, Rotterdam and The Hague also mention the link between shared mobility and transport poverty. These municipalities see shared mobility as an instrument to reduce transport poverty. As a result, the providers are expected to distribute shared cars more evenly in these cities, so that the demographic dimension is less related to the availability of shared cars. This would therefore mean that the local government intervenes in the geographic and service dimension. Therefore hypothesis 3 states:

3. *In the cities of Rotterdam and The Hague, where the social perspective on shared mobility is included in the mobility policy, there are less strong relationships between the predictors of transport poverty and the number of shared cars than in Amsterdam and Utrecht.*

1.4.2 Research question

This study tested the hypotheses to clarify the distribution of shared cars among the neighborhoods in the cities of Amsterdam, Rotterdam, The Hague and Utrecht. This distribution tested how demographic and geographical factors are related to the number of shared cars available in a neighborhood. Finally, it was tested whether municipal policy with regard to shared mobility and transport poverty ensures that shared cars are more evenly distributed throughout the city in Rotterdam and The Hague. By testing these hypotheses, the research question can be answered:

To what extent is the demographic composition of a neighborhood related to the availability of shared cars in the four largest cities in the Netherlands, and to what extent does government policy focus on carsharing as an answer for the risk of transport poverty?

2. Research methods

2.1 Data collection

The hypotheses have been tested with data which is publicly available in the Statline program by CBS. The data that CBS makes available every year contains key figures for all municipalities, districts and neighbourhoods in the Netherlands. The CBS-data was obtained by consulting various registers. It will be briefly explained for each variable which registers have been used and what has been done to guarantee the privacy of people. The dataset from 2018 was used for this study because this is the most recent dataset in which the required variables are measured.

The CBS data has been supplemented with an extra variable that shows the number of shared cars (B2C) with a fixed location per district or neighbourhood. This data was obtained by counting shared cars in the period between 20-4-2021 and 28-4-2021. The websites of MyWheels, Greenwheels, Juuve, We Drive Solar and Connectcar, the providers of carsharing in the G4, were used to determine how many shared cars there are per district and neighbourhood.

2.1.2 Operationalization of the variables

From the data made available by CBS and available in the literature, 9 variables have been selected that are applicable to the demographic and the geographic dimension. The variables were measured for each city, district and neighbourhood. Districts are part of a municipality and consist of one or more neighbourhoods. The division in the Wijk- en Buurtindeling (WBI) was used to determine the boundaries between neighbourhood, district and cities. The WBI is a geographic distribution determined by the municipalities. The values for each variable are the mean value for district or neighbourhood. As a result, in this study the N is determined by the number of districts or neighbourhoods.

2.1.2.1 Demographic / demand dimension

Income

The variable *income* is operationalized on the basis of the average income per income recipient. CBS has based the average income per recipient on the tax registers of the Ministry of Finance and on the basic registration of municipalities. The average includes the income of people who have earned income from work, their own business, income insurance or social security (with the exception of child benefit). The figures are only known in districts and neighbourhoods where at least 2,500 people live.

Employment rate

The percentage of people who have a job is measured by the original variable *Employment rate*. Labour participation is stated as a percentage of the total number of persons aged 15 to 75 years and was measured when a minimum of 150 inhabitants work in a neighbourhood. The variable labour participation only includes employees and the self-employed.

Migration background; Western and Non-Western

The operationalization of the variable *Migration background*, consists of two different variables. The variables are divided into Western and Non-Western based on their country of birth. Persons with a migrant background originating in one of the countries in the continents of Europe (excluding Turkey), North America and Oceania or Indonesia or Japan fall under the variable Western. The category 'Non-Western' includes persons with a migrant background from Turkey, Africa, Latin America and Asia with the exception of Indonesia and Japan. Someone has a migration background when the person has at least one parent who was born abroad. The variables *Western* and *Non-Western* existed in the original dataset as totals, but were converted into percentages of the total number of inhabitants in use.

Age

The variable *Age* consists of five different categories, namely 0 to 15 years, 15 to 25 years, 25 to 45 years, 45 to 65 years and 65 years or older. The ages are measured as of January 1 and are subdivided by age category. In the age categories, only the number of people within a category is measured. The age classes initially consisted of absolute numbers, but were converted to percentages for the regression analysis. Only the categories 25 to 45 years and 65 years or older were used in the regression analysis. Because 25 to 45 is a group that uses a shared car more often and the group 65 and older falls into the risk group for transport poverty.

Men

The variable *Men* comprises the percentage of men in a district or neighbourhood on 1 January. This data was obtained by CBS by analysing the population registers per municipality. People who for various reasons are not included in the population registers therefore do not appear in this variable. In addition, CBS has rounded the values for gender to multiples of 5 to guarantee statistical confidentiality. For the purposes of this study, total values have been converted to percentages.

Car ownership

The variable *Car ownership* indicates the average number of passenger cars per household. This concerns the number of registered passenger cars per private household that were registered on 1 January in the vehicle registration of the National Road Transport Agency (RDW). Because passenger cars registered at the address of a lease or rental company distort the car density per household, only the number of passenger cars per household is stated for a minimum of 50 households and a value of a maximum of 2.5 passenger cars per household.

2.1.2.2 Geographic dimension

Population density

The (unrounded) number of inhabitants per km² of country is determined by the variable *Population density*. This has been calculated by dividing the (unrounded) number of inhabitants on 1 January by the (unrounded) land area. The population density is included if there are 10 or more inhabitants in the neighbourhood.

2.1.2.3 Service / supply dimension

Number of shared cars per district/ neighbourhood

The variable *Number of cars per district/neighbourhood* has been operationalized by the number of shared cars per district or neighbourhood. Only the providers of shared cars that offer B2C with a traditional carsharing supply are counted and included.

2.1.3 Data management

The CBS dataset has been made available by CBS on its own website. To use the data, the dataset is downloaded. After this, the shared cars per district and neighbourhood were counted. The values of the number of shared cars per district and neighbourhood were added to the downloaded dataset from Statistics Netherlands after the count. Variables and areas not used in the analysis have been removed from the dataset. For the analysis of the data, the dataset was transferred from Excel to SPSS (version 26) with which the analyses were also performed.

2.1.4 Data structure

Before performing the analyses, two choices were made in selecting the data that influence the results. First of all, it was decided to analyse Amsterdam at district level and Rotterdam, The Hague and Utrecht at neighbourhood level. This was chosen because Amsterdam has very small neighbourhoods at neighbourhood level, often with fewer than 2500 inhabitants. As a result, variables such as income often had missing values. It was also not possible to analyse all cities at district level because Rotterdam, The Hague and Utrecht have too large districts. This would make the analyses less detailed.

Secondly, it was decided not to use districts and neighbourhoods where the value for income is unknown. This has two underlying reasons. First of all, these are neighbourhoods where the value on a variable is often missing on several variables. In addition, this often includes industrial areas where only a small number of people live. After all, income is unknown in neighbourhoods with fewer than 2500 inhabitants. Including these types of areas would give a very distorted picture of the results. Due to this choice, 157 areas were not included in the analyses.

2.1.5 Data analysis

To determine whether different dependent variables have different effects between the four cities, a stepwise multilevel analysis was first performed (Heck et al, 2014). First, it was determined on the basis of the intraclass correlation coefficient (ICC) and the level 2 variance estimate whether the predictors should be analyzed in clusters. ICC values of less than 0.5 are indicative of poor reliability, meaning that there are no indications for large differences between data groups, in this study the different cities. (Koo & Li, 2016). If the ICC score is lower than 0.5, a regression analysis without control of a multilevel analysis is sufficient.(Field, 2018, p.746).

$$ICC = \frac{\sigma_B^2}{\sigma_B^2 + \sigma_W^2}$$

For the regression analyses, The VIF scores and Cook's distance and leverage values will be analyzed to check for multicollinearity and outliers. The VIF scores were tested against the measures from Field (2018, p242) to determine to what extent the multicollinearity is harmful to the interpretation of the results. In order to recognize which variables correlate with each other to what extent, the correlation values were requested and the interaction effects between correlating variables will also be measured. Finally, the regression analyses tested the extent to which the demographic and geographically dependent variables influence the number of shared cars and thereby hypotheses 1a, 1b and 2. The regression analyses were also performed per city to test hypothesis 3 in addition to the multilevel analyses.

3. Results

3.1 Descriptive statistics

The table below shows the descriptive statistics of the independent variables, the demographic and geographic variables and the dependent variable, the number of shared cars. The first column contains the values in the G4 and the other columns the values per city.

Table 1

Descriptive Statistics for the G4 and each City Separately

	G4 (N=259)				**Amsterdam (District N=79)**				**Rotterdam (Neighbourhood N=59)**				**The Hague (Neighbourhood N=72)**				**Utrecht (Neighbourhood N=49)**			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Income (x1000)	19	95	34.43	11.15	23	95	37.89	13.40	21	57	30.90	8.23	19	71	33.03	11.18	20	56	35.12	8.34
Employment rate (%)	48	82	66.31	7.74	59	78	68.37	5.41	48	79	62.86	6.93	48	79	63.08	7.57	49	82	71.86	7.94
Western (%)	5.96	34.99	15.86	6.42	9.23	34.99	19.36	6.34	6.94	31.59	13.01	4.67	5.96	34.02	17.60	6.66	7.51	17.81	11.06	2.42
Non-Western (%)	3.66	87.48	33.42	19.74	9.47	71.47	32.07	17.01	6.30	78.54	38.64	18.77	5.14	87.48	36.48	22.83	3.66	67.71	24.81	17.34
25-45 (%)	14.02	58.78	33.58	8.10	22.63	58.78	37.27	8.00	18.38	52.65	30.79	7.24	14.02	43.23	30.24	6.96	18.17	55.14	35.89	7.71
65+ (%)	2.97	54.29	12.80	6.03	2.97	28.73	12.28	4.79	6.74	30.30	14.57	5.43	4.38	54.29	13.75	7.92	3.31	21.70	10.14	4.08
Men (%)	41.59	55.63	49.39	1.91	45.91	55.63	49.68	2.08	46.35	53.14	49.39	1.56	41.59	53.39	49.47	2.05	43.96	51.47	48.80	1.71
Car ownership	.20	1.30	.63	.24	.20	1.30	.45	.20	.40	1.2	.67	.21	.20	1.20	.70	.25	.40	1.20	.68	.25
Population density	1436	28139	11354	5943	1436	28139	13276	7345	1949	20687	8462	5525	1945	21944	11795	4917	1610	20323	9359	4067
Number of shared cars	0	61	8	9.52	1	61	15.19	12.13	0	40	5.46	7.40	0	16	3.22	3.61	0	29	6.49	5.77

3.2 Multilevel analyses

Table 2 tests whether a multilevel analysis is necessary to test the regression coefficients. From model 1 in table 2, the explanatory variance of four cities shows that there are no indications for hierarchy in the nested data (P=.177). The ICC also points out that the difference between cities may have no significant influence on the further results.

ICC (*model* 1) = *19.931/ (67.346+ 19.931) ≈ 0.228*

In model 2 of table 2, shows the variance with the demographic and geographic variables included. The ICC has decreased and the effect of that cities is still not significant (P=.253). This means that the regression lines in one city are not significantly different than in another city, which makes a multi-level analysis for the interpretation of the regression coefficients unnecessary.

ICC (model 2) = 3.462 / (39.317 + 3.462) ≈ 0.081

Table 2

Results of Multilevel Analyse Examining the Hierarchy Influence of Cities

					95% Confidence interval	
Parameter	**Estimate**	**Std. Error**	**Wald Z**	**Sig.**	**Lower bound**	**Upper bound**
Model 1:						
Residual	67.346	5.963	11.293	.000	56.616	80.110
Intercept (subject = City) Variance	19.931	14.727	1.353	.176	4.683	84.819
Model 2:						
Residual	39.318	3.485	11.283	.000	33.048	46.777
Intercept (subject = City) Variance	3.462	3.031	1.142	.253	.623	19.252

Dependent Variable*: Number of shared cars.*

3.3 Regression analyses

Table 3 presents the results of the regression analysis, where Employment rate (VIF = 6.568, t = .152) and Non-Western (VIF = 5.873, t = .170) showed remarkable VIF values. The correlation output shows that Employment rate strongly correlates with Income (.536) and negative with Non Western (-.676). Non-Western also strongly correlates negative with Income (-.671). Despite the fact that the VIF values are so high, the variables in the regression analyses have been preserved. After all, it is known that neighborhoods have socio-economic characteristics that can be interrelated.

Hypotheses 1a, 1b and 2

The regression model with the number of shared cars as dependent variable and income, employment rate, migration background, age, gender, car ownership and population density as independent variables is significant, F (9, 249) = 31.763, $p < .001$. The regression model can therefore be used to predict the number of shared cars, and this model explains substantial amount of variation: 53 percent of the differences in the number of shared cars can be predicted (R2 = .534). The variables Income, b = .422, t = 6.745, $p < .001$, Employment rate, b = .585, t = 4.295, $p < .001$, and Car ownership, b = -.24.768, t = -7.576, $p < .001$, have a significant correlation with the number of shared cars in the neighborhood. Population density also has a significant effect, but the effect is marginal, b = .000, t = 2.926, p = .004. The estimated number of shared cars increases by 1 per average income of 2369 euros. When the employment rate increases by 1.71%, the number of shared cars increases by 1 and when the average car ownership in a neighborhood increases by 0.1, the number of shared cars decreases by -2.48. The results of the regression analysis are in line with hypotheses 1a and 1b, but provide no evidence to support hypothesis 2.

Hypothesis 3

Although the multilevel analysis showed no significant differences between cities, the regression analysis per city shows that the effect for income (b = .132, t = .695, p = .490) in Amsterdam is not significant and that car ownership in only the city of Utrecht has a significant negative relationship with the number of shared cars (b = -16.025, t = -3.264 , $p < .000$). Finally, there is no significant effect for Employment rate in any of the cities separately. Although there are minimal differences between cities, there are no results in line with hypothesis 3.

Table 3

Regression Analyses: Demographic and Geographical Characteristics of a Neighbourhood and the Number of Shared Cars

	G4 (N=259)		**Amsterdam (N=79)**		**Rotterdam (N=59)**		**The Hague (N=72)**		**Utrecht (N=49)**	
Variables	B	SE B	B	SE B	B	SE B	B	SE B	B	SE B
Constant	-48.881*	17.403	6.687	70.568	-87.462	36.603	5.690	12.660	-22.583	22.971
Demographic / demand dimension										
Income (x1000)	0.422***	0.063	0.132	0.190	0.599***	0.136	0.295***	0.045	0.367*	0.135
Employment rate (%)	0.585***	0.136	0.414	0.574	0.238	0.295	0.077	0.106	0.228	0.219
Migration background										
Western (%)	0.081	0.108	0.185	0.580	-0.576	0.273	-0.053	0.064	-0.096	0.349
Non-Western (%)	-0.044	0.051	-0.214	0.162	.043	0.106	-0.017	0.036	0.012	0.078
Age										
25-45 (%)	-0.212	0.108	-0.588	0.286	0.414	0.301	0.175	0.084	-0.150	0.136
65+ (%)	0.229	0.125	-0.237	0.556	0.437	0.266	-0.040	0.069	-0.162	0.215
Men (%)	0.364	0.295	0.088	0.830	1.195	0.751	-0.380	0.207	0.195	0.393
Car ownership	-24.768***	3.269	-13.219	9.096	-22.149	9.855	-6.410	3.122	-16.025***	4.484
Geographic dimension										
Population density	0.000**	0.000	0.000	0.000	0.000	0.000	0.000**	0.000	0.001**	0.000
R^2	0.534		0.346		0.532		0.678		0.680	

(Dependent variable: Number of shared cars).

*p < .05, **p < .01, and ***p < .001

4. Discussion

4.1 Findings

The study of the policy documents of the four largest municipalities in the Netherlands illustrated that these municipalities aim to use carsharing to solve spatial problems and to make the vehicle fleet more sustainable. Only Rotterdam and The Hague paid attention to potential role of carsharing in reducing transport poverty. Because no specific policy is pursued to direct market parties in the allocation of shared cars, significantly fewer cars are available in less prosperous neighbourhoods. This study showed that if income increases by an average of 2369 euros per year, the number of shared cars will increase by 1. The study also showed that employment rate has a similar effect when the cities are tested together. The number of shared cars in a neighbourhood increases by 1 if there are 1.71% increase of employed people living there. Although the study found no significant relationship between migration background and the number of shared cars present in a neighbourhood or city, there is a negative correlation between Non-Western residents, employment rate and income. Although, Rotterdam and The Hague want to use shared mobility against transport poverty, the distribution of shared cars is not better regulated than in Amsterdam and Utrecht.

In short, the distribution of shared cars is related to the demographic variables income and employment rate. This means that people with less socio-economic backgrounds also have fewer options on the geographic and service dimension. The different dimensions not only influence the capability set, but are also interrelated. In addition, there are no indications that local governments with a social perspective in their policy on shared mobility actually make more shared cars available in neighbourhoods with an increased risk of transport poverty than other cities.

4.2 Discussion

In this study, Sen's capability set and Rashid's model were used. The data that corresponds to the different dimensions has been used. But an important, but difficult to measure variable that is also missing from Rashid's model is the will of people. With the lack of demand for shared mobility, providers will also not want to place cars. Providers can also steer their offer based on usage. This information is lacking in this study and can have a strong influence.

In this study, the weighting of the indicators of transport poverty is equal. It is likely that one indicator outweighs the other. In addition, accessibility indicators play an important role in the risk of transport poverty. The proximity of a public transport connection, facilities or employment reduces the risk of transport poverty. In order to properly test the link between shared mobility and transport poverty, a broader range of variables will have to be quantitatively tested in a follow-up study, followed by qualitative research to test the experience of people with transport poverty. In a follow-up study, techniques from spatial planning could contribute to get more insight. This study shows that in the G4 shared cars are not equally available in every neighbourhood and that it is strongly related to socio-economic background.

4.3 Recommendation

Despite the fact that municipalities see the possibilities of shared mobility for reducing transport poverty, there are no specific policy goals and instruments. It is therefore recommended that the G4 authorities set specific objectives and devise appropriate instruments to make shared cars available to everyone if they see shared cars as a solution to transport poverty. Municipalities will have to actively steer providers on where they park the shared cars and at the same time encourage residents to make use of shared mobility. In addition, follow-up research should be conducted into who exactly experiences transport poverty and how these people can participate in shared mobility. The follow-up study should clarify the thresholds that hinders high-risk groups from using the shared car.

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6 Appendices

6.1 Syntax

```
* Rename the variables into English names .
RENAME VARIABLES (gm_naam Aantal_inwoners Huishoudens_totaal Aantal_deelautos
Gemiddeld_inkomen_per_inkomensontvanger Netto_arbeidsparticipatie
Personenautos_per_huishouden Bevolkingsdichtheid
= City Inhabitants Households Number_sharedcars Mean_income Employment_rate Car_ownership
Population_density) .

* Change citynames into values .

RECODE City ('Amsterdam'='1') ('Rotterdam'='2') ("'s-Gravenhage"='3') ('Utrecht'='4').
ALTER TYPE City (f4) .
VALUE LABELS City 1 "Amsterdam" 2 "Rotterdam" 3 "The Hague" 4 "Utrecht" .
FREQUENCIES City .


* Recode to percentages .
Compute Non_westernnew = Niet_westers/Inhabitants*100 .
DESCRIPTIVES Non_westernnew .

Compute Westernnew = Westers_totaal/Inhabitants*100 .
DESCRIPTIVES Westernnew .

Compute Age25_45 = T25_tot_45jaar/Inhabitants*100 .
Compute Age65high = oudste_groep/Inhabitants*100 .
DESCRIPTIVES Age25_45 Age65high .

COMPUTE Percentage_men = mannen/Inhabitants*100 .
DESCRIPTIVES Percentage_men .



* Remove neighbourhoods with too little inhabitants (Income is only known by 2500 inhabitants. (27
neighbourhoods have more than 2500 inhabitants, but the mean income is unknown)) * .

FREQUENCIES Mean_income .
Filter by Mean_income .

* -----------------------* .
* descriptives statistics for G4 .
EXAMINE VARIABLES=Mean_income Employment_rate Non_westernnew Westernnew Age25_45
Age65high
   Percentage_men Car_ownership Population_density Number_sharedcars
  /PLOT NONE
  /STATISTICS DESCRIPTIVES
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.

* descriptives statistics for each city .
```

```
EXAMINE VARIABLES=Mean_income Employment_rate Non_westernnew Westernnew Age25_45
Age65high
   Percentage_men Car_ownership Population_density Number_sharedcars BY City
  /PLOT NONE
  /STATISTICS DESCRIPTIVES
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.


* Model (1) random intercept model .

MIXED Number_sharedcars
  /CRITERIA=DFMETHOD(SATTERTHWAITE) CIN(95) MXITER(100) MXSTEP(10) SCORING(1)
   SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0, ABSOLUTE)
PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=| SSTYPE(3)
  /METHOD=ML
  /PRINT=G DESCRIPTIVES SOLUTION TESTCOV
  /RANDOM=INTERCEPT | SUBJECT(City) COVTYPE(VC).

* Intercept = 7,608460 (sig = .029)
* Estimates of covariance parameters
          Residual = 67,345846 (sig = .000)
          Intercept (subject = City) = 19,930521 (sig = .176)
* ICC (intraclass correlation coefficient) = 19,930521 / (67,3458468 + 19,930521) =

* Model (2) random intercept model + addition of 1 level predictors .

MIXED Number_sharedcars WITH Mean_income Employment_rate Non_westernnew Westernnew
Age25_45
   Age65high Percentage_men Car_ownership Population_density
  /CRITERIA=DFMETHOD(SATTERTHWAITE) CIN(95) MXITER(100) MXSTEP(10) SCORING(1)
   SINGULAR(0.000000000001) HCONVERGE(0, ABSOLUTE) LCONVERGE(0, ABSOLUTE)
PCONVERGE(0.000001, ABSOLUTE)
  /FIXED=Mean_income Employment_rate Non_westernnew Westernnew Age25_45 Age65high
Percentage_men
   Car_ownership Population_density | SSTYPE(3)
  /METHOD=ML
  /PRINT=CORB DESCRIPTIVES G  SOLUTION TESTCOV
  /RANDOM=INTERCEPT | SUBJECT(City) COVTYPE(VC).

* Correlation between Employment_rate & Non_western is high (.765)
* Estimates of fixed effects (significant variables)
        Mean_income         .362140 (.000)
        Employment_rate      .404293 (.004)
        Car_ownership        -19.717737 (.000)
        Population_density     .000323 (.001)
* Estimates of covariance parameters
          Residual = 39,317772 (sig = .000)
          Intercept (subject = City) = 3,462121 (sig = .253)
```

* ICC (intraclass correlation coefficient) = 3.462121 / (39.317772 + 3.462121) = .08092869704 > .05 .
(too low, what means that a very small part of the variantie is accounted for clustering) .

* Model (3): No sigificant differents on citylevel, what means that a regression analyse fits .

```
*For all cities .
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Number_sharedcars
  /METHOD=ENTER Mean_income Employment_rate Non_westernnew Westernnew Age25_45
Age65high
    Percentage_men Car_ownership Population_density
  /RESIDUALS DURBIN
  /SAVE COOK .


*Amsterdam .
REGRESSION
  /SELECT=City EQ 1
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Number_sharedcars
  /METHOD=ENTER Mean_income Employment_rate Non_westernnew Westernnew Age25_45
Age65high
    Percentage_men Car_ownership Population_density
  /RESIDUALS DURBIN.

*Rotterdam .
REGRESSION
  /SELECT=City EQ 2
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Number_sharedcars
  /METHOD=ENTER Mean_income Employment_rate Non_westernnew Westernnew Age25_45
Age65high
    Percentage_men Car_ownership Population_density
  /RESIDUALS DURBIN.

* The Hague .
REGRESSION
  /SELECT=City EQ 3
  /MISSING LISTWISE
```

```
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Number_sharedcars
  /METHOD=ENTER Mean_income Employment_rate Non_westernnew Westernnew Age25_45
Age65high
    Percentage_men Car_ownership Population_density
  /RESIDUALS DURBIN.

*Utrecht .
REGRESSION
  /SELECT=City EQ 4
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Number_sharedcars
  /METHOD=ENTER Mean_income Employment_rate Non_westernnew Westernnew Age25_45
Age65high
    Percentage_men Car_ownership Population_density
  /RESIDUALS DURBIN.
```