A city-level analysis of B2C carsharing in Europe

Master's thesis

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Summary

Business to consumer (B2C) carsharing is a phenomenon that started in Europe in the 1940s but has gained in popularity quickly since the 1990s. This development is a welcome addition to the means that can be supported by local governments in order to mitigate greenhouse gas emissions and curb congestion in cities. Cities have however experienced differences in the extent to which carsharing has been adopted in their area. This research uncovers several important city features that explain this differential adoption of carsharing in a city.

This study uses the multi-level perspective (MLP) to distinguish between the contemporary car regime and the carsharing niche. Several indicators are identified that theoretically would weaken the regime and/or strengthen the niche in a city. These indicators are therefore expected to have a noticeable effect on the amount of shared B2C vehicles in cities, as the local car regime would be weaker.

The research develops a unique database by collecting the amount of shared B2C cars online through carsharing operator (CSO) websites. Independent variables are in turn collected through various sources both on- and offline, including national statistics databases and Eurostat. Results are initially analyzed through bivariate correlations. Subsequently, a binary logistic regression and a negative binomial regression analysis are employed to determine the most important explanatory variables for the success of B2C carsharing.

The research shows that B2C carsharing success can be reasonably explained through the country in which the city is situated, the city size in terms of its population, the level of car ownership, the education level of the city's inhabitants, the city's modal split, the extent to which the city's population is engaged with sustainability, the competition between B2C CSOs, and to some extent the presence of students and attempts to provide explanations for the significance of these variables.

This research is intended to be an exploratory study on the characteristics of cities where B2C carsharing is successful. Several suggestions for further research that can add to the insights gained here are adding other variables, more data points (countries or smaller cities), and more detailed data.

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1. Introduction

1.1 Car problems and solutions

Urban regions suffer from several commonly identified problems such as congestion, noise, energy use, and parking shortage (Loukopoulos et al., 2005). Especially air quality is a major concern as it directly affects the health of a city's inhabitants. Across both Europe and North America, emissions of many air pollutants are highly concentrated in urban areas (see Pouliot et al., 2012). Many of these, such as NO_x, PM, CO, and uncombusted hydrocarbons, are the direct result of road transport (Kousoulidou et al., 2008). Even when exposed to levels of $PM_{2.5}$ below the required European limits of 25 μg/m^3, a significant health risk is still present (Beelen et al., 2014). It is therefore of interest to each regional government how this multitude of problems can be resolved as much as possible.

In an attempt to tackle these issues, governments have historically tried to increase shared vehicle use, mainly through supporting carpooling (also called ridesharing), where drivers provide a ride to other passengers in their own car (Vanoutrive, 2012; Handke & Jonuschat, 2013). With the emergence of the internet and the smartphone, such ridesharing has increased in popularity (Handke & Jonuschat, 2013). Since the 1990s another transportation phenomenon has quickly grown in popularity, and also makes extensive use of smartpones: *carsharing* (Shaheen & Cohen, 2008).

1.2 Carsharing

Carsharing is a type of short-term vehicle access upon which a multitude of business models (see Figure 1) are based (Shaheen et al., 2015). There are two major types of carsharing: peer-to-peer (P2P), where users get in touch with car owners who are willing to rent out their personal vehicles, and business-to-consumer (B2C), where firms own a fleet of vehicles that they rent out. Within the B2C type of carsharing, there are two dominant subtypes: one-way, where a car can be rented at one location and dropped off in another, and return-trip, where cars have to be dropped off in the same location it was rented from. Finally, there is one more dichotomy in the one-way carsharing business model which is between free-floating, where cars can be rented and dropped off in any location within the designated operating area, and station-based, where a car has to be picked up and dropped off at available stations.

Carsharing addresses all the common problems identified in urban regions by reducing the distances driven in private vehicles (Shaheen et al., 2002; Shaheen et al., 2003). More specifically, research indicates that especially for B2C carsharing there is a positive impact on the environment by reducing the emission of air pollutants and greenhouse gasses (GHGs) (Rodier & Shaheen, 2003; Cervero & Tsai, 2004; Firnkorn & Müller, 2011; Martin & Shaheen, 2011; Baptista et al., 2015; Chen & Kockelman, 2015; Namazu & Dowlatabadi, 2015).

There are important differences between P2P carsharing and B2C carsharing which inhibit the ability to study them as the same phenomenon. One reason is that in sum there are many more shared P2P cars listed as available than there are shared B2C cars available. However, Snappcar, one of the largest Dutch P2P carsharing organizations (CSOs), indicated during the Carsharing Symposium in June 2015 at Dutch governmental organization *Rijkswaterstaat* in Utrecht, the Netherlands that a car listed on their website is rented out an average of only seven times per year. Shared B2C cars on the other hand need to be rented out much more frequently to make its provision economically feasible for a company.

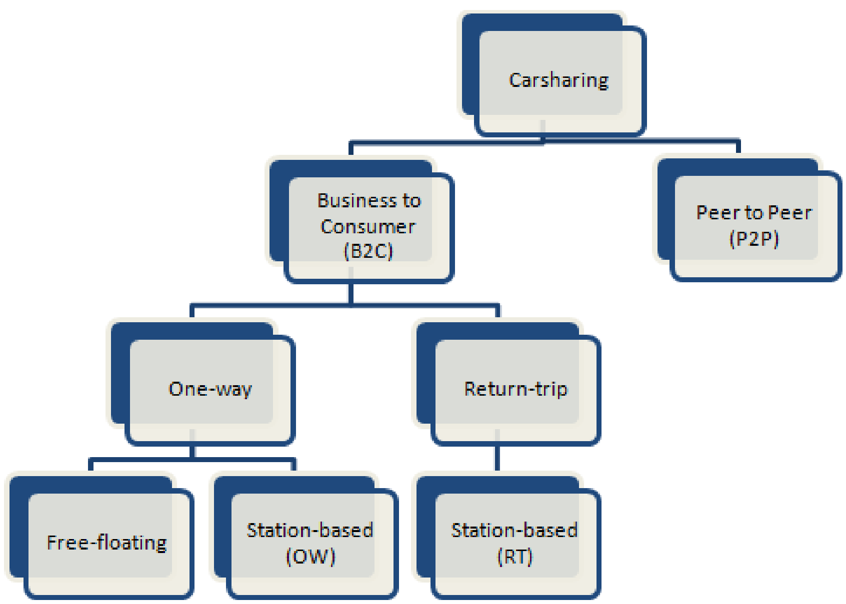

Figure 1 - Different business models of carsharing.

Such differences in frequency of use are important when researching the success of carsharing. This is because measuring success would be most appropriate when success is defined as the frequency of use of a shared car. There is however no public data available of what exactly the usage of each shared car is. The amount of shared cars has therefore previously been used as indicator of the success of carsharing (e.g. Celsor & Millard-Ball, 2007; Meelen et al., forthcoming). However, due to the disparity between the frequency of use of a shared P2P car and shared B2C car, the success of P2P and B2C carsharing cannot be expected to be comparable when indicated by the amount of shared cars unless a correction for the frequency of use is adopted. Since such frequency of use data is not available, B2C carsharing and P2P carsharing should be studied separately when using vehicle counts as indication of success.

1.3 The purpose of this research

This thesis will focus on the B2C business model as it has a significantly higher potential to contribute to emission reductions than P2P carsharing. Combining the low frequency of renting out a shared P2P car with the fact that the average private vehicle is used for only one hour per day (Shaheen et al., 1998; Meijkamp, 1998; Umweltbundesamt, 2008), B2C carsharing vehicles can realistically achieve a much higher usage rate than P2P carsharing vehicles based on the current practices. This means that because B2C cars are used more intensively they will also have to be replaced sooner. This allows for more energy efficient, less polluting models to be adopted more quickly. Additionally, B2C CSOs can decide to make their fleet completely electric, furthering the investments in environmentally friendly ways of transportation.

Research into the success of B2C carsharing in different cities is relevant for both the public and the private sector. A question that warrants attention from a regional policy perspective is: "What can we learn from other cities with regard to the effectiveness of carsharing in our city?" A similar question can be asked from the perspective of a CSO: "In which cities will our business have a high chance of success?" These are valid questions because the carsharing level of service (i.e. number of carsharing vehicles available) varies across cities. This indicates that in some cities carsharing has seen more success than in others. Since the early years of carsharing research, a multitude of studies has been performed that identified various factors that influence the carsharing level of service (Klintman, 1998; Shaheen, 2000; Meaton & Low, 2002; Millard-Ball et al., 2005; Celsor & Millard-Ball, 2007; Coll et al., 2014). None of these studies have however been performed at the European city level. The vast majority of these studies also look at preferences of individuals, rather than city-level metrics.

For the efficient development of carsharing throughout Europe, it is therefore invaluable to know what has defined the selective successes of existing carsharing initiatives in European cities. The question that this research will attempt to answer is therefore:

> ***What explains the differential adoption of B2C carsharing across European cities?***

1.4 Research implications

The outcome of this research has both scientific and societal implications. From a scientific perspective, the database developed for this research can be used and elaborated upon in the future in order to monitor the development of carsharing in Europe. Future research can build upon the methodology developed here to maintain a comprehensive carsharing database. Additionally, further insight is gained into the role of cities with regards to the geography of transitions.

From a societal perspective, insight into what determines the success of a carsharing initiative is valuable in order for policy makers to efficiently devise policy when required in the formative stages of the carsharing phenomenon. Since increasing returns to adoption is an important driver of diffusion (and subsequently a transition) and "certainly applies to carsharing" (Frenken, 2013 - p. 13) the earlier an overview of whether carsharing may be a success or not in a particular region, the better. This is because, as Arthur (1989) indicates in his seminal work on increasing returns to adoption and market share outcomes, policy measures may lose effectiveness based on whether several business models are still competing, or one business model has already cornered the market.

1.5 Thesis structure

In order to determine how to approach this question, we take a step back and look at carsharing and its place in the economy. It is part of an economic development that emphasizes sharing. Despite the fact that sharing has been part of the economy for a long time already (Price, 1975; Belk, 2010), it recently has garnered much media attention. This is in part because the companies *Uber* and *Airbnb* - initiatives claiming to be part of the so called "sharing economy" - stir up the hive by competing with the incumbent taxi and hotel industries. Such developments, where niche industries (in this case so-called ridesourcing and the sharing of living space) challenge incumbent regimes (the taxi industry and the hotel industry), are clear examples of transitions taking shape. Similar to these initiatives, the carsharing niche is aiming to challenge transportation by private vehicles. Various theories dealing with transitions have been extensively used to analyze sustainability transitions (Geels, 2002; Hekkert et al., 2007; Kemp et al., 2007; Schot & Geels, 2008). However, firms such as Zipcar and Car2Go have (contrary to Uber and Airbnb) not received such strong resistance from an incumbent regime. So can carsharing be considered a substitute to car ownership or complementary to it?

Preliminary data indicates that most carsharing users did not have a personal vehicle before they joined the carsharing service (Martin & Shaheen, 2011), which would point at carsharing being a complementary service. However, it is also clear that there are many users who give up car ownership or forego the purchase of a car when joining a carsharing initiative (Millard-Ball et al., 2005; Shaheen et al., 2009; Martin et al., 2010; Nijland et al., 2015). This means that there is definitely a niche market consisting of people who infrequently require a private vehicle for whom carsharing is an ideal solution. Chapter 2 will deal with these theoretical questions related to placing carsharing in the context of existing literature.

Measuring carsharing success is done by looking at the level of service, but how is the level of service determined? What cities are included in the research and how is the data analyzed? These questions are answered in chapter three which will detail the methodology that is used.

Chapter four will detail what the most important features are of the cities that explain the carsharing level of service.

Chapters five and six finally summarize the conclusions and address several points for discussion respectively.

2. Theoretical foundations

In order to understand what carsharing is and how to theoretically embed the phenomenon, we first look at carsharing from the perspective of the sharing economy. Subsequently we analyze and define carsharing as a phenomenon. Then we take a look at three transitions theories and compare them. This is followed by highlighting a specific theory, the multi-level perspective, and explaining how this theory will allow us to analyze carsharing at a city level.

2.1 Defining the sharing economy

The carsharing phenomenon can be characterized as being part of the sharing economy (Schor, 2014). The term sharing economy was first used to describe the contemporary phenomenon of buying access to goods from other users/consumers by Lawrence Lessig from Harvard University in 2008 (Lessig, 2008). Lessig indicated that next to a commercial economy, which is regulated by prices, there is "also a sharing economy, where access to culture is regulated not by price, but by a complex set of social relations" (Lessig, 2008). Since this initial definition of the sharing economy, the importance of social relations has remained a core value in many of the businesses that have been founded under the umbrella of the sharing economy (such as Peerby, Thuisafgehaald, MyWheels, and Getaround) and is also deeply embedded in many firms that claim to be part of the sharing economy through rating systems (where users can be rated on the quality of their service or product). However, there is much more to the sharing economy than social interaction. This becomes evident when looking at the ongoing discussion with regard to the exact definition of the sharing economy. It has been established that a clear definition would be beneficial to the ongoing debate on the sharing economy and which firms can claim to be part of it (Botsman, 2013; Meelen & Frenken, 2014; Schor, 2014). Several attempts at a definition have been made by scholars; here three of them are highlighted.

Rachel Botsman defines the sharing economy as follows: "An economic model based on sharing underutilized assets from spaces to skills to stuff for monetary or non-monetary benefits" (Botsman, 2013). Here, underutilized assets are the focal point. Toon Meelen and Koen Frenken agree to a large extent with this definition, but are stricter in their own definition. They namely define the sharing economy as "the phenomenon that consumers let each other use their idle capacity of consumption goods, potentially against payment" (Meelen & Frenken, 2014). Here, specifically consumers are the actors providing the "idle capacity". Juliet Schor consolidates these definitions to some extent, in the sense that she acknowledges that payment is not a required feature and she indicates that both consumers and firms can be the actors providing the asset or service (she doesn't mention idle capacity or underutilization). As a result, she splits the sharing economy in four broad categories where each sharing economy initiative is either for profit or non-profit, and either peer-to-peer (P2P) or business-to-consumer (B2C) oriented. Publicly available carsharing would (depending on the business model) fall either in the for profit P2P or B2C category. This research focuses solely on the B2C variant of carsharing.

2.2 Defining carsharing

Defining carsharing is, similar to defining the sharing economy, a difficult task. Many governments have however required a definition of carsharing in order to distinguish which firms are and which are not allowed to benefit from certain tax-breaks and other legislation that benefits carsharing initiatives (Millard-Ball et al., 2005). In this regard, governments have been very pragmatic by defining it as "car vehicles put at the disposal of members against payment for a limited duration of use according to contractual conditions determined by (the car-sharing organization), to the exclusion of car rental and leasing" such as the draft definition of the Belgian national government (Rydén & Morin, 2004; p. 34). However, by including everything that looks like car rental and leasing but isn't, it may become very difficult to exempt from benefits those services that self define as carsharing when in fact they are a leasing or car rental company.

Koen Frenken employs a more useful definition that is "a system that allows people to rent locally available cars at any time and for any duration" (Frenken, 2013 - p. 9). This definition more concretely defines the service that is being offered by those firms that are considered to be part of the sharing economy.

We can also define carsharing from a user's perspective by continuing with the definition of the sharing economy posed earlier. In this case, the crucial part in the distinction between carsharing and traditional car rental lies in the involvement of users. Traditional car rental companies require the car rental attendant to fulfill many tasks. These are to a large extent performed by the users in carsharing. For P2P carsharing this is very evident, as the rental procedure is transferred to non-professional users. User involvement can be more difficult to identify for B2C carsharing than for its P2P counterpart, however when you think of certain tasks such as checking the fuel level and ensuring that it is sufficient for the next user to be able to drive the vehicle, submitting their driver's license details, and retrieving as well as storing the keys after using the vehicle, one can see the role of the user is much more active with B2C carsharing than with car rentals and leasing. With the help of ICT these tasks, that have routinely been part of a full-time job at a rental company, are executed by users.

Both the definition from a service perspective and from a user's perspective encompass the same type of firms that provide automobility similar to a car rental or leasing service, but do not include car rental or leasing services due to their user involvement and local orientation. These are considered to be the carsharing organizations (CSOs).

2.3 Transitions theories

As was established earlier, carsharing is part of a transition from private automobility to shared automobility. But what transitions theories are out there and what can they tell us? Transitions theories stem from the field of innovation studies, where among other things the emergence and diffusion of new products, services, and processes is explained. Transitions have been a core subject of research for scholars studying sustainable development since innovation studies can provide a perspective on what happens when products, processes, and services that are environmentally beneficial are developed and introduced to a society in order to replace damaging alternatives (Smith et al., 2010). To this end, several theories have been put forward in order to understand and explain these phenomena better. Three of these theories are briefly discussed and compared while finally settling on one particular perspective that the research is based on. The three theories that are discussed are the Technological Innovation System, Transition Management, and the Multi-level Perspective.

2.3.1 The Technological Innovation System

The Technological Innovation System (TIS) is a theory used to describe and understand the development of a particular technology and is often applied to the energy sector (Jacobsson & Bergek, 2004; Negro et al., 2007; Hekkert & Negro, 2009; Suurs et al., 2009; Negro et al., 2012; Wieczorek et al., 2013). The theory's foundations emerged in the early nineties (Carlsson & Stankiewicz, 1991) and was given shape on two similar accounts in the Netherlands and in Sweden and both accounts highlight their usefulness for policy making (Hekkert et al., 2007; Bergek et al., 2008; Jacobsson & Bergek, 2011; Wieczorek & Hekkert, 2012). They describe that the successful emergence of a technology is determined by a set of "functions" or critical processes that need to take place in the development of the technology to make it a success. In these functions, many stakeholders, such as governments, firms, NGOs, and consumers, are involved.

2.3.2 Transition Management

Transition Management (TM) is also a theory that is particularly useful for policy makers as it was developed in order to address the requirement for a way to analyze systemic innovation and support environmental transitions from the perspective of the government (Kemp & Loorbach, 2003). The theory describes how from a governmental perspective transitions can be spurred through distinguishing visions, learning, and communication between many stakeholders (Kemp et al., 2007).

2.3.3 The Multi-Level Perspective

The Multi-level Perspective (MLP) describes the interplay between the three concepts of landscape, regime, and niche (Geels, 2002). According the MLP, a successful transition is achieved when pressure on a contemporarily dominant technological regime accumulates from factors external to the regime and from emerging niche technologies. When this pressure is high enough, the niche can gradually substitute the regime and become the new regime (Geels, 2002). MLP's usefulness in analyzing sustainable transportation transitions has been indicated before (Geels, 2012; Mejía-Dugand et al., 2013).

All three theories have great similarities as they are all based on the evolutionary economic thinking developed by Nelson & Winter (1982). This means, among other things, that all three theories recognize the importance of the process of variation, selection, and retention when discussing technological evolution. They also recognize that transitions happen not only at the technological level, but across society including technology, but also policy, cultural meaning, markets, consumer practices, and scientific knowledge (Kemp et al., 1998; Geels, 2004). However, when attempting to describe the relationship between an existing practice and an emerging one, a clear advantage of MLP is that it also emphasizes that what happens outside the niche. Additionally, since this thesis does not particularly focus on taking a policy perspective on carsharing, and aims to describe the situation at hand, MLP is most suited to analyze the situation at hand.

2.4 About the Multi-level Perspective

MLP analyzes technological transitions by describing the interplay between three levels: the landscape, the regime, and the niche (Geels, 2002). These three levels provide a useful theoretical framework to analyze what influences the ability of a niche to emerge as a dominant regime. Rip & Kemp define technological regimes as "the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures" (Rip & Kemp, 1998 - p. 340). Geels however highlights that not only engineers are included in the regime, but many other actors such as users, NGOs, scientists, governments, etc. He therefore calls it a *socio*technical regime (Geels, 2002). Because of the ubiquity of the regime and the interconnectedness of the system, it is difficult to change the regime.

The regime is embedded in an environment termed the landscape. This landscape is "a set of deep structural trends" (Geels, 2002 - p. 1260). These trends are external to the sociotechnical regime and the landscape is therefore even more difficult to influence than the regime. Change in the landscape thus takes place very gradually, but external shocks, such as wars and economic crises are examples of landscape influences that can influence the sociotechnical (ST)-regime in short time-spans.

Finally, the niche is where radical innovations are generated (contrary to the regime where incremental innovations are generated). The regime's market selection criteria do not apply to the niche, effectively rendering them isolated. The radical innovations that emerge in these niches are crude or 'hopeful monstrosities' (Mokyr, 1990) and isolation gives time for learning processes to take place and the niche to develop.

The three different levels - landscape, regime, and niche - are hierarchically nested within each other: the niche is the micro-level which is nested within the regime level at the meso-level. Finally, the regime is nested in the landscape at the macro-level (Geels, 2002). This means that the success of a niche is not only determined by what happens at the niche level, but also by the states of and events that take place at the level of the landscape and the regime. The temporal nature of these events suggests that a temporary window of opportunity for a niche to break through can be created. This happens when tensions in a regime arise, the landscape exerts pressure on the regime, the niche develops a dominant design, or a combination of any of these events (Geels, 2002).

2.5 Transitions and geography

Transitions theories are accused of neglecting or marginalizing the geographical component in transitions (Coenen et al., 2012). And indeed, intrinsically the MLP does not pay attention to the geographical context. However, geography can and has been taken into account in transitions studies (Coenen et al., 2012; Dewald & Truffer, 2012; Hansen & Coenen, 2014; Sengers & Raven, 2015). This work argues that transitions "are not pervasive, but happen in particular places" (Hansen & Coenen, 2014; p. 4). Hansen & Coenen (2014) list a multitude of studies that shows that a wide range of themes may influence the transition in a geographically confined space. These themes are visions and policies, local institutions, natural resource endowments, technological and industrial specialization, and market formation (Hansen & Coenen, 2014). This thesis acknowledges the inherent lack of a geographical component in transition theories and pays attention to the possible effect of geography on the transition. It does so by acknowledging local differences in the regime and niche and comparing variables between different geographical locations.

2.6 Applying MLP to carsharing

The carsharing phenomenon can be described in the context of the MLP. Whether carsharing has the potential to be successful at the city level is then the result of the interplay between the local landscape, regime, and niche. Analyzing these three contexts at the city level allows for a general idea of the potential for carsharing to successfully emerge in different cities.

The research will focus on a particular niche and regime. Describing the landscape becomes only useful after the niche and regime have been defined because the landscape encompasses factors external to the regime and niche.

2.6.1 Defining the regime: the car as mode of transportation

The operationalization of regimes has been subject to criticism in the past. It was argued that there were no clear guidelines on how the concepts should be applied empirically (Berkhout et al., 2004). The issue was described to be one more related to the definition of the scope of one's research. The regime thus needs to be defined based on the scope of the research (Geels, 2011).

This research is concerned with the role of B2C carsharing in relation to contemporary society. It is therefore useful to define the regime as one of the car as means of transportation. The strength of this regime is for example reflected by the car infrastructure that is globally invested in (roads, traffic rules and laws, strong institutionalization of driving education, etc.), and cars per capita in the developed world, including Western Europe commonly being over 500 cars per 1000 persons in 2010 (Worldbank, 2014).

The sociotechnical regime of cars consists of the complex interaction between all actors, artifacts, institutions, and organizations involved in propagating the car as main vehicle of transportation (see Figure 2.1).

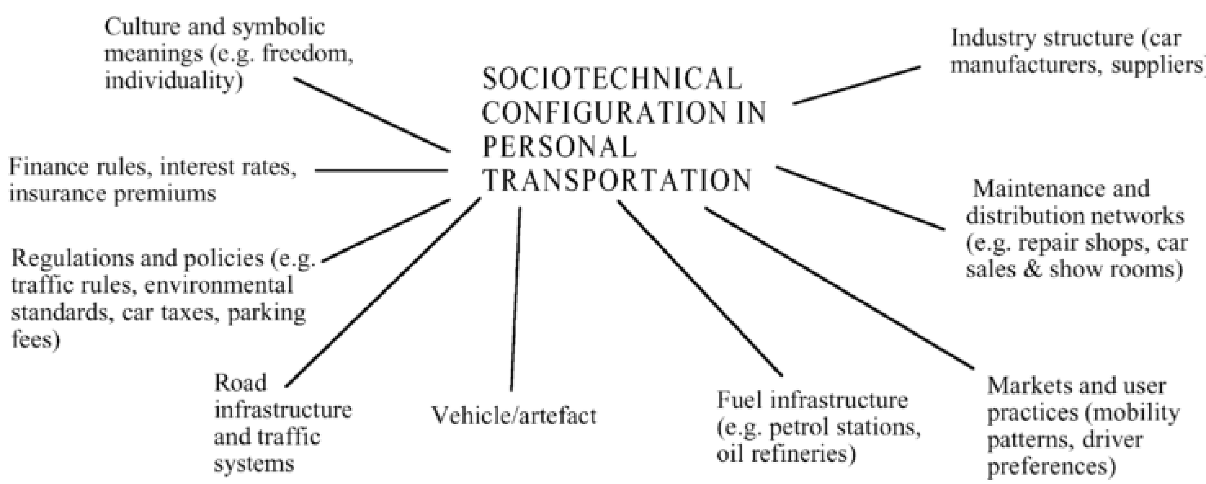

Figure 2.1 - The sociotechnical regime of personal transportation of cars. The ubiquity of the car as the main vehicle of personal transportation is also confirmed by the author of the figure who only considers the car when describing the regime of personal transportation in general. Source: Geels, 2002.

One could also argue that that the regimes being challenged is that of the rental, public transit, and taxi regimes and therefore these regimes should be adopted as focal regimes of this study. This would be justified by the stated alternatives of carsharing users if carsharing would not have been available from a survey by Millard-Ball et al. (2005). Here, of those that still would have made the trip if carsharing was not available, 20% would have used public transit, 12.6% would have used a rental car, and 10.6% would have used a taxi service (Millard-Ball et al., 2005). So one might ask themselves whether is it not these forms of transportation that carsharing is directly substituting? This is however not the case. Comparing the modal split of carsharing users with that of non-users of carsharing, shows that more kilometers are made with public transit, taxi, and car rental by carsharing users than non-users (Harms & Truffer, 1998 citing Baum & Pesch, 1994; Cervero et al., 2006). So it does not appear that taxis, car rentals, and public transit are directly threatened: they are still used by users of carsharing. These regimes are therefore not the correct regimes for this research to focus on.

2.6.2 Defining the niche: B2C carsharing

The niche that is being compared to the car regime is that of carsharing. More specifically, it is all publicly available B2C carsharing active in Belgium, Germany, France, the Netherlands, and the United Kingdom. Niches are generally protected from regular market selection mechanisms in order to provide an environment where a "crude" innovation is a competitive alternative allowing for the innovation to develop and become more refined (Schot, 1998). Carsharing has been shown to require protection to a certain extent in the shape of policy in order to increase the viability of carsharing in city environments where parking is expensive (Shaheen et al., 2010). The niche is further "protected" in the sense that it solves local problems (e.g. congestion, parking costs) giving it access to a local market.

This relates directly to the relationship that carsharing has with the car regime: one of symbiosis. As mentioned earlier, the role of carsharing is rather similar to car rental, public transit, and taxi services. They all have in common that they are alternatives to the current global standard of using a car for all distances of travel. And even more so, just like car rental and taxi services, carsharing is closely intertwined with the dominant car regime as it uses its infrastructure and suppliers, as well as parts of its institutions (traffic legislation and driver licenses for example). Carsharing is therefore easily adopted as an addition to the regime. This relationship between the niche and regime closely resembles the transition pathway described as a "Transformation" path by Geels & Schot (2007). The relationship between niche and regime can be further described along the characteristics of the Transformation transition pathway. The moderate landscape pressure takes the shape of common problems related to mobility in the city. The landscape pressures are the result of events that are external to the regime and generally change slowly (e.g. cultural norms, political coalitions, environmental problems, emigration). In order for the pressure to result in changes in the regime, they need to be recognized which is a common role for actors outside of the regime. In the context of carsharing this translated itself to many outside entrepreneurs starting the city-wide carsharing initiatives. These provided the necessary conditions for the carsharing niche to emerge and provide an on-demand, cost-competitive mobility service. Regime insiders' perceptions have been changed to such an extent that many incumbent car producers are setting up their own carsharing initiatives (e.g. BMW, Daimler, Ford, Citroën).

It is important to understand that different types of carsharing have different relationships with the regime. This is clear when looking at the difference between P2P and B2C carsharing. In the case of P2P carsharing, the niche is more complementary to the regime as optimal adoption of P2P carsharing would invoke very limited changes in the car regime. This is because B2C, in contrast to P2P carsharing, does not rely on the regime notion of private ownership of a vehicle in order to exist. B2C carsharing would therefore invoke certain changes within the regime if it were to be optimally adopted. Such changes are predominantly linked to the distribution of the ownership structure in the car regime. In the contemporary car regime ownership is dominated by private ownership. Next to private car ownership, there are only a few alternatives that are nowhere near as successful as private car ownership. These are ownership structures such as leasing, renting, and driving services (such as taxis). B2C carsharing promotes a shift of car ownership from individuals to companies (who are potentially also the manufacturers). Such a shift will not completely substitute private car ownership since private car ownership is still a very successful form of ownership for those individuals that need car access frequently. Thus, although carsharing is mostly complementary to the regime, it seriously challenges some of the more established forms of ownership, especially for those individuals that don't use a car as often.

Additionally, the culture around cars as a symbol of freedom and individuality, as well as the role of cars as status symbol would be very different from the contemporary state of the regime.

2.6.3 Defining the landscape

The landscape is the contemporary state of society and the environment. In the case of carsharing, relevant events that are part of the landscape include, but are not limited to, the financial crisis in 2008 and the subsequent recovery, and trends among consumers. Also the common problems that cities struggle with, such as air quality, congestion, and expensive parking space can be considered landscape pressures. These are all factors external to the regime and are assumed to be similar for all considered cities.

2.6.4 Features affecting the car regime

Even though the landscape is considered to be similar for different cities, the regime strength is not. Regime strength can be influenced by the international, national, and local context.

In the international context, private vehicle ownership is related to international travel and government subsidies. With regard to international travel, several services must be available to private vehicle owners, also abroad, such as public access to gas stations, the availability of roadside assistance, the availability of parking spaces, road maintenance, etc. Subsidies from countries in their car manufacturers may affect private car ownership internationally (Davey, 2011). Getting subsidies for new research centers and bailouts for car manufacturers in financial trouble strengthens the car manufacturing sector. It keeps competition high and as a result it may drive down prices for consumers. It can additionally lead to quicker technology development, making privately owned vehicles more attractive than alternatives. For the purposes of this research, the international context is considered to be uniform throughout Europe, and thus it is not taken into consideration for the research.

At the national level, the regime can also be influenced in several ways. Strong support for the regime at the national level can also come from the subsidy of car manufacturers and car ownership in several European countries (Davey, 2011). This supports the car manufacturers by (among other ways) incentivizing consumers to buy new (electric) vehicles (e.g. through tax breaks). By making private car ownership more affordable, this supports the private car ownership regime. Additionally, the reliability, affordability, and availability of a national rail transit service can positively or negatively affect the strength of the regime. It is therefore expected that carsharing success varies between European countries.

H.1: The success of B2C carsharing is different between European countries.

At the local level, differences in the regime strength can be expected between cities. Land in cities can be considered a scarce good, i.e. if more people want it, it gets more expensive. This would increase the costs of car ownership and the difficulty with which one can find a parking spot among other regime-inhibiting effects. Therefore, it is expected that carsharing is more successful in cities where population density is high.

H.2: B2C carsharing is more successful in cities with a higher population density.

In some cities people may already own a vehicle. Due to the sunk costs that are associated with such a purchase, these would be less inclined to use B2C carsharing as a primary mode of transportation. Therefore, it is expected that carsharing is less successful in cities where car ownership per capita is high.

H.3: B2C carsharing is less successful in cities where car ownership is higher.

Similarly, when many people use a private vehicle for their daily commute, they will have a private vehicle available to them, whether it is a leased vehicle from work, or a privately owned vehicle. Having access to a privately owned vehicle will make these people less inclined to use carsharing. It is therefore expected that carsharing is less successful in cities where the modal split favors car-based commutes.

H.4: B2C carsharing is less successful in cities where the share of cars in commutes is larger.

Reliability, affordability, and availability of local public transit options such as busses and light rail can affect car ownership. One can reasonably expect that in a city where the modal split favors public transit the car ownership regime is weaker than in a city where the modal split favors private vehicle transport. This is a direct result of people who are able to make use of a well-established public transit system will not need a car as often to get them from one place to the other. Hence, for such groups of people the need of a privately owned vehicle is lower (and therefore those that own a car are also more likely to sell their current car). It is therefore expected that carsharing is more successful in cities where the modal split favors public transit.

H.5: B2C carsharing is more successful in cities where the share of public transit in commutes is larger.

Socio-demographic factors have previously shown to be an important indicator of carsharing success (Coll et al., 2014). When looking for higher educated populations, "smartness" of cities has been proxied through the city's "importance as a knowledge center" (Giffinger et al., 2007). One of the ways this was done was by looking at local research center or university rankings. But cities with universities also have an increased amount of young people with a high education. When combining all these factors, it is therefore expected that carsharing is more successful in cities where a highly ranked university is present.

H.6: B2C carsharing is more successful in cities where a university is present.

The urban form in the sense of the local infrastructure, such as parking facilities, road quality and quantity, and areas restricted for cars in cities can also negatively affect private car ownership and the car regime and as a result favor carsharing (Coll et al., 2014). In the literature on the urban form it is established that urban form affects sustainability and automobile use (Wheeler, 2003; Vance & Hedel, 2007). Such urban form can be found in old city centers which were not built for cars. They contain many narrow streets, one-way streets, and generally have a lack of parking availability. It is therefore expected that carsharing is more successful in cities with an old city center.

H.7: B2C carsharing is more successful in cities that have old city centers.

2.6.5 Features affecting the B2C carsharing niche

Next to regime strength, the niche strength too can be considered to be embedded within a local context.

For a niche to succeed, they need a market. In the case of carsharing, the users are individuals. Markets are therefore assumed to be larger in cities that are larger in population. To accommodate for a larger market, more cars will need to be made available for use. Therefore, it is expected that carsharing is more successful in cities with a larger population.

H.8: B2C carsharing is more successful in cities that have a larger total population.

The niche can also be strengthened when the population prefers the niche over the regime inherently. Young people and people with a higher education are shown to be more willing to adopt innovations at an earlier stage of their development (Rogers, 1962). It is therefore expected that carsharing is more successful in cities where one or multiple of these population groups have a large representation in the total population.

H.9: B2C carsharing is more successful in cities that have a higher proportion of young people.

H.10: B2C carsharing is more successful in cities that have a higher proportion of inhabitants with a higher education.

Household composition has been shown to be related to a household's susceptibility to adopt carsharing (Millard-Ball et al., 2005; Celsor & Millard-Ball, 2007). Families with children can be expected to prefer to own a private vehicle to take care of the transportation needs of their offspring. Therefore it is expected that carsharing is more successful in cities where there is a larger proportion of one-person households.

H.11: B2C carsharing is more successful in cities with a larger proportion of one person households.

Environmental awareness has also been shown to influence the adoption of sustainable innovations such as carsharing (Hidrue et al., 2011; Dastrup et al., 2012). Many Western European countries have a political party that puts a lot of emphasis on environmental issues (e.g. Groenlinks in the Netherlands, Groen (Dutch) and Ecolo (French/German) in Belgium, Europe Écologie – Les Verts in France, Die Grünen in Germany, and the Green Party in the United Kingdom). When people vote for these "green" political parties, they can be reasonably assumed be environmentally aware. Meelen et al. (forthcoming) found that neighborhoods with higher proportion of people who vote for the green political party had a significantly larger amount of shared cars. It is thus expected that carsharing is more successful in cities where the green party received a higher share of votes in the most recent election.

H.12: B2C carsharing is more successful in cities where the green political party received a higher share of the votes in the latest election.

The presence of a university may also be a proxy for the presence of a large group of students in the city. These younger people are more inclined to adopt a new service (Rogers, 1962) and are generally unable to afford a private vehicle. In order to satisfy their desire for freedom of mobility they may turn to carsharing.

H.13: B2C carsharing is more successful in cities where the share of the student population is larger.

The concept of shared mobility may be foreign to people who have only known private car ownership as the mode of transportation to work towards obtaining. However, when a city contains a similar shared mobility concept, inhabitants may be more acquainted with shared mobility and its features. Bikesharing is such a form of shared mobility. Carsharing is therefore expected to be more successful in cities that contain a bikesharing program.

H.14: B2C carsharing is more successful in cities containing a bikesharing program.

The literature on the geography of firm formation indicates that agglomeration economies come with advantages for the location of new firms. One of these advantages is the "spatial proximity to large numbers of customers" (Fritsch et al., 2006). It is therefore expected that carsharing is more successful in cities that are close to the headquarters of a carsharing CSO.

H.15: B2C carsharing is more successful in cities where a CSO is headquartered.

As carsharing grows and more CSOs emerge competition among CSOs also increases. This competition may spur more innovation as firms try to gain a competitive advantage over competitors (Rogers, 1962; Utterback, 1996). It is therefore expected that carsharing is more successful in cities where multiple CSOs compete.

H.16: B2C carsharing is more successful in cities where there is more competition between CSOs.

Apart from the CSO, city demographics, and urban form, also governments can affect the success of carsharing. Supportive policy is indeed recognized to play an important role in sustainability transitions (Geels, 2002; Schot & Geels, 2008; Meelen & Farla, 2013) and also in the success of carsharing (Meelen et al., forthcoming; Shaheen et al., 2010). It is therefore expected that carsharing is more successful in cities where policy supportive of carsharing is present.

H.17: B2C carsharing is more successful in cities where policy supportive of carsharing is present.

3. Methodology

The research will be based on the quantitative analysis of all publicly available B2C CSOs in cities in five European countries. This quantitative analysis will be able to identify correlations between pre-defined variables and explain the success of carsharing in each city.

3.1 Unit of analysis

As established earlier, when perceiving the MLP in a geographical context, the strength of the regime can vary significantly in different geographical settings. The success of carsharing has been analyzed previously on the level of neighborhoods (Celsor & Millard-Ball, 2007; Meelen et al., forthcoming) and towns/cities (Meaton & Low, 2003; Barth et al., 2006; Coll et al., 2014). As the aim of this thesis is to compare regions across Europe, the city level is a balance between granularity and practicality.

3.1.1 The definition of a city

Not all countries have the same definitions for similar geographical areas, making city regions difficult to compare. Until recently, this ambiguity of definitions "undermined the comparability, and thus also the credibility, of cross-country analysis of cities" (Dijkstra & Poelman, 2012; p. 2). In 2011, the European Commission (EC) therefore developed a definition of a city together with the OECD with the specific aim to resolve this problem (Dijkstra & Poelman, 2012; OECD, 2012). I will provide a simplified description of how the city is defined and how this was used for this study. For a detailed description of how the city is defined exactly, I would like to refer to the respective documents by the EC (Dijkstra & Poelman, 2012) and OECD (OECD, 2012).

The definition is based on a grid overlaying a geographical map (see Figure 3.1). The simplified definition of a city by Dijkstra & Poelman (2012; p. 2) is as follows:

"Step 1: All grid cells with a density of more than 1,500 inhabitants per sq km are selected.

Step 2: The contiguous high-density cells are then clustered, gaps are filled and only the clusters with a minimum population of 50 000 inhabitants are kept as an 'urban centre'.

Step 3: All the municipalities (local administrative units level 2 or LAU2) with at least half their population inside the urban centre are selected as candidates to become part of the city.

Step 4: The city is defined ensuring that 1) there is a link to the political level, 2) that at least 50 % of city the population lives in an urban centre and 3) that at least 75 % of the population of the urban centre lives in a city."

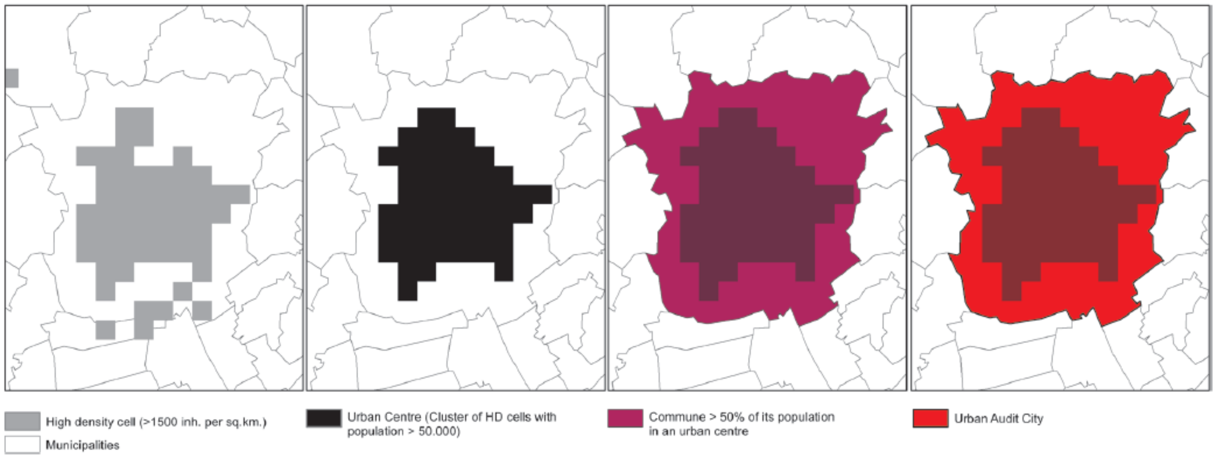

Figure 3.1 - Four steps in the definition of a city. (Image from Dijkstra & Poelman, 2012; p. 2)

The fourth step is crucial to this definition's backward compatibility with data collected at the political level (e.g. municipalities). It is however not fully compatible with the voting districts in Germany, France, and the UK as voting districts cross municipal boundaries (see Figure 3.2 for an example). Even though this definition is not perfect for every independent variable that is to be collected, it is still the best available option for city definition in the context of this research for several reasons:

1) Data availability: Eurostat, an important source of statistics at the city level in Europe, uses the same definition for a city;
2) Geographical scalability: this definition is aligns with the OECD city definition which is useful when expanding the study to include the United States of America and other countries; and
3) Population specificity: a focus on the populated city core makes it a better definition than for example the NUTS3 level, in which populated areas are often grouped in regions together with rural areas; and
4) Backwards compatibility: the definition is linked to political boundaries at the municipality level which allows for data collected at this level to be aggregated to the level at which the city is defined.

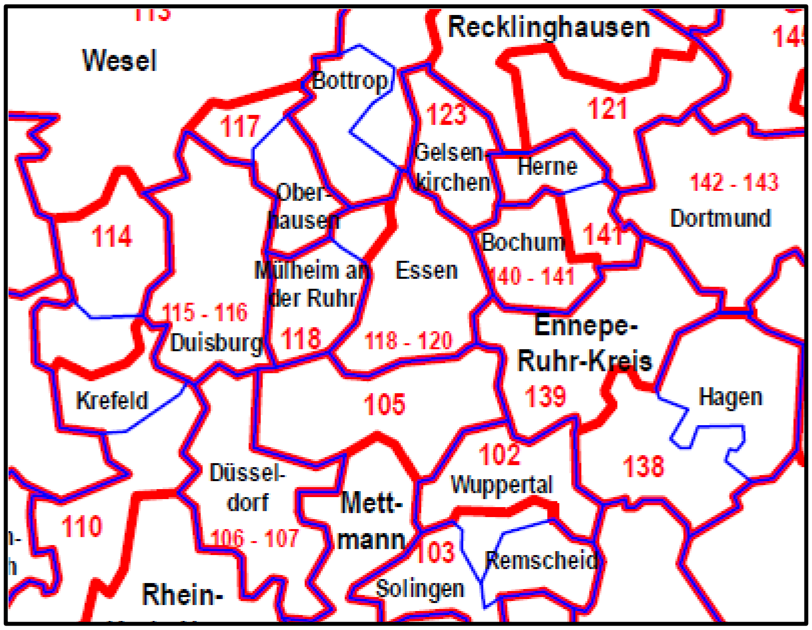

Figure 3.2 - The blue municipal boundaries (Kreisgrenze) overlaid on the red voting district boundaries (Wahlkreisgrenze) for the Ruhr area in Germany. (Image from Bundeswahlleiter, 2008)

3.1.2 The selection of cities

Cities need to be of adequate size, as B2C carsharing operations settle in the largest cities. The selection criteria for the cities are therefore as follows:

1) The city must lie in one of the following countries: (a) Belgium, (b) Germany, (c) France, (d) the Netherlands, and (e) the United Kingdom; and
2) The city must have more than 150,000 inhabitants based on the latest census.

This has led to a selection of 177 cities based on population data from Eurostat (see Table 3.1). The available year for population statistics varied per country, and as such the latest available data was used. For a full list of all the eligible cities per country, see Appendix 1.

Table 3.1 - The selection of cities by country

Country	Year	Eligible cities
Belgium	2013	5
Germany	2014	53
France	2012	46
The Netherlands	2013	13
United Kingdom	2013	60
Total	-	177

3.2 Dependent variable data collection

3.2.1 Measuring success

In this thesis, success is measured based on the supply of carsharing (as opposed to the demand). In line with previous research, the supply of shared B2C cars is considered to be a proxy for the amount of demand (Celsor & Millard-Ball, 2007). This is since it can be reasonably expected that firms will only offer vehicles when these are being utilized efficiently. Even though government subsidies and other support for carsharing may initially encourage increasing supply, they are only a short-term incentive as subsidies are expected to only last briefly when there is insufficient demand in the long-term (Millard-Ball et al., 2005; Price & Hamilton, 2005).

3.2.2 Selection of carsharing platforms

The active carsharing platforms are identified in the cities that conform to the criteria set above. The platforms are limited to those that offer vehicles owned by the company that are publicly available. This means that next to P2P two other "forms" of carsharing are also omitted. One is the neighborhood initiative where a vehicle is purchased by a group of people or households that share the car using a private system. The other is business-to-business carsharing, where a CSO provides a fleet of vehicles to a large firm for their employees to share. These types are not included in the analysis as vehicle data is for these types are not openly available. This results in a list of 58 individual carsharing organizations active in at least one of the selected 177 cities. See Appendix 2 for the full list of carsharing platforms.

3.2.3 Data collection methods

Since there are many different ways in which CSOs display their vehicles on their website, data cannot be collected in the same manner for all websites. Several methods that are employed are listed here, arranged from the method getting the most detailed data to the least detailed:

- For some websites, map views and list views of vehicles can be collected in bulk through a "json" file. The data contained in this file can be very detailed (including street names and geographical coordinates at the 5-6 decimal accuracy). The detailed information allows us to determine whether a car is within the defined city limits or not. However, there are several drawbacks related to this data collection method. This method only works for a very limited amount of CSO websites. Additionally, it can be difficult to determine the meaning of various variable IDs given by the CSO website, especially when different CSOs use different labels and IDs. This means that the data needs to be extracted in a unique way for each website. The types of data provided within the json file also vary per CSO. Although common types are vehicle number, latitude and longitude, and vehicle type, these will most likely not be available on every CSO website.
- If it is not possible to collect the data as described above, the search tools of the site are used to gather the number of cars per city. This often leads to list-views of cars. If this is the case, an attempt will be made to extract the list-view data using the software from https://www.import.io/.
- Here, car locations are verified through the municipality in which the car is located.

If it is not possible to gather the exact number of cars through a search, the amount of cars are manually counted on the map when a map is available. The map is compared to a map of the defined city limits in order to ascertain that only cars that are within the limits are counted.

- In case there is no map available and none of the above methods have worked, the amount of cars is inquired with the CSO. This method is only necessary for B2C CSOs as P2P CSOs have to list their vehicles on their website. This is due to the fact that cars have to be individually selected by the customer, which is not the case for B2C.

Using any of these methods, the total amount of shared cars per city can be determined by adding up the amount of shared cars per CSO for each city.

Care needs to be taken however between the different terms used between different countries to indicate carsharing. In the Netherlands and the Dutch speaking parts of Belgium, carsharing is also called "autodelen", a literal translation of carsharing. In Germany "carsharing" tends to be the dominant term and there is no local, German form. In the United Kingdom, "carsharing" is used to indicate what in general would be called ridesharing, instead they use "car clubs" when talking about what otherwise would be called carsharing in other parts of the world. And finally in France the terms "autopartage" and "voiture en libre service" are used.

3.3 Independent variable collection

There are fourteen independent constructs that are considered for the purpose of this study (see Table 3.2). They have one or two measurement variables each. Of the measurement variables, eleven are taken from European statistics database Eurostat.

However, when using aggregated data from a statistics database, one has to keep in mind the ecological fallacy that may arise when using individual level statistics to measure city level phenomena (Robinson, 1950). Taking individual metrics is namely only useful when the mean is representative of the whole population. This does not have to be the case when looking at demographic data of cities. Where possible, metrics are used that indicate the distribution of data rather than using statistics based on the mean.

Not all variables are complete for each city unfortunately, which means that some cities may be omitted from the results analysis. Each of the variables that are not collected through Eurostat involved varying degrees of difficulty collecting the data. Here the collection process of these variables will briefly be discussed.

3.3.1 Population density

Population density is collected from the official national statistics databases. Either through a direct measure of the population density, or from geographical area data combined with population data. All data is aligned with the city definition according to Eurostat/European Commission.

3.3.2 Sustainability awareness

A city with a larger proportion of people who are concerned with sustainability is expected to have a higher vote for the national "green" political party. The votes for the green political parties are gathered independently for each country. Even though each country has different green political parties, they were easily identified as they are all members of the European Green Party. The political parties identified are as follows: "Ecolo" and "Groen" in Belgium, "Bündnis 90/Die Grünen" in Germany, "Europe Écologie – Les Verts" in France, "GroenLinks" in the

Netherlands; and "Green Party of England and Wales", "Green Party in Northern Ireland", and "Scottish Green Party" in the United Kingdom. Votes for these parties are comparable across countries as they all embody similar goals and ideologies. This is reflected in their collaboration with other green parties in Europe under the banner of the European Green Party in the European Parliament.

Table 3.2 - Operationalization table

Construct	Measurement variable	Source (year)
Dependent variable		
Success of car sharing	Amount of shared cars per city	CSOs/CSO websites (2015-2016)
Independent variables		
Country level differences	Country	Eurostat (2016)
City population	City population	Eurostat (FR: 2012; BE, NL, UK: 2013; DE: 2014)
Population density	Population density	Statistics Belgium (2008), Statistische Ämter (2013), Insee (2012), CBS (2015), Office for National Statistics (2011)
Young population	% of population 20-24 years	Eurostat (BE, DE, FR, UK: 2012; NL: 2013)
	% of population 25-34 years	
	% of population 35-44 years	
One person households	% of one person households	Eurostat (UK: 2011; DE, FR: 2012; 2013: BE, NL)
Car ownership	Cars per capita	Eurostat (BE, NL, UK: 2011; FR: 2012; DE; 2014)
Education level	% of population higher educated	Eurostat (DE, UK: 2011; FR, NL: 2012; BE: Missing)
Modal split favoring transit	% of commutes by car	Onderzoek Verplaatsingsgedrag Nederland (2010 / 2011 / 2012), Eurostat (BE: 2008; FR, UK:
	% of commutes by transit	
Sustainability awareness	% of votes for green party	Agentschap voor binnenlands bestuur (2012), Service public de Wallonie (2012), Brussels Hoofdstedelijk Gewest (2012), Der Bundeswahlleiter (2013), Assemblée Nationale (2012), Kiesraad (2012), The Electoral Commission of the United Kingdom (2015)
Presence of students	% students relative to city population	Eurostat (BE: 2011; NL: 2012; DE, FR, UK: 2013)
	Presence of a university	Leiden university ranking (2015)
Urban form	City has had a population >= 10000 by the year 1800	De Vries: European Urbanization 1500-1800 (1984)
Acquainted with sharing economy	Presence of bikesharing	Bikeshare.com (2015)
History of carsharing	Presence of CSO HQ	CSOs/CSO websites (2015-2016)
Competition among CSOs	Herfindahl index of B2C market	CSOs/CSO websites (2015-2016)
City policy	Presence of carsharing policy	Municipalities (2016)

The collection of the data is done through the official websites for each country's election results. As Belgian voting data is not available for the national elections, they are collected for the municipal elections in 2012 instead and only valid votes were considered. German voting data is collected for the "Bundestagswahl" in 2013 and only the valid "Zweitstimmen" are taken into consideration. French voting data is taken from the "Élections Légeslatives" in 2012 and only the valid votes of the first voting round are taken into consideration. Dutch voting data is taken from the "Tweede Kamerverkiezingen" in 2012 and only valid votes are counted. British voting data is taken from the "United Kingdom general election" in 2015 and again only valid votes are counted.

All votes are collected at the level of the voting district. As mentioned in section 3.1.1, the boundaries of these voting districts are at times defined differently from political boundaries. Subsequently, all voting districts with at least partial geographical overlap with the defined city are included in the data. This is because since there is no indication of the distribution of votes in a city, it may be that votes for a particular party are higher in certain neighborhoods than others. This is especially a concern when considering the potential influence of gerrymandering.

3.3.3 Presence of students

Next to being measured through the amount of students in the city relative to the city population, the presence of a university is also documented. This is based on the presence of a university in the CWTS Leiden ranking of universities. This ranking includes 750 universities globally with the highest proportion of articles in the top 10% of their field. The CWTS Leiden ranking was selected due to its additional suitability as a potential measure for city education level. This measure was eventually dropped in favor of the available Eurostat statistic on the amount of highly educated people in a city, however the statistic for university presence remains.

3.3.4 Urban form

With regards to urban form, the goal is to determine which cities have a historic city center. Such a city center is not designed to be easily accessible for cars. The definition of this variable was very dependent on data availability. The book "European Urbanization 1500-1800" (De Vries, 1984) provided data on the population of cities that at one point contained 10,000 or more inhabitants between 1500 and 1800. The definition of a city with a historical city center is therefore determined to be any city that was mentioned in this database. Cities of this size at that time are considered large enough to have formed an established city center around which the rest of the town grows.

It may be argued that the urban form of old cities could have been altered as a result of the Second World War. Old cities that were bombed may have rebuilt with a more car-friendly city center. There are however two problems when putting this approach into practice. Firstly, no comparable data on the extent to which a city has been bombed/rebuilt is available. The data ranges from the absolute amount of houses that were destroyed, to the percentage of the city that was destroyed (however it is unknown whether this percentage is based on the geographical area of the city, the amount of buildings, or otherwise), and even to qualitative terms such as "heavily bombed" or not. Secondly, it cannot be expected that every city that was destroyed to the extent that the majority of buildings needed to be rebuilt, decided to rebuild their city while keeping in mind to accommodate cars. Neither can it be expected that cities either did, or did not do so. They may very well be a vast amount of cities that rebuilt some areas as they were before they were bombed, and some areas as completely new. Such information requires a qualitative research into how cities were rebuilt after the Second World War. Due to the difficulties associated with processing such bombing data, it is not taken into consideration in the study.

3.3.5 Acquainted with sharing economy

To measure to what extent a city's inhabitants may be acquainted with the sharing economy the presence of a bikesharing program is in recorded. The data is gathered through the map available on the website Bikeshare.com. The map contains all cities that have a running bikeshare program. The map is being kept up to date.

3.3.6 History of carsharing

In order to measure the length of time a CSO has been operational in a city, the presence of a CSO in a city is used. This is measured by gathering the locations of the CSOs' headquarters from the CSO websites or by asking them directly.

3.3.7 Competition among CSOs

Competition among CSOs is defined by identifying the Herfindahl index or Herfindahl-Hirschmann Index (HHI). This is a measure of defining the concentration of an industry (Weinstock, 1982). The measure is the sum of the squared market shares of all firms in the industry. The index ranges from a theoretical maximum value of 1, indicating very high concentration (a monopoly), and the closer the value comes to 0, the lower the concentration and thus more competitive the industry is deemed to be. The geographical boundaries of the market are defined as the geographical city as defined earlier, and the market is defined as the total amount of shared B2C cars. A more accurate representation of the market would be the total amount of trips with shared vehicles, but this data is unavailable. Therefore, a reasonable assumption is made that CSOs are profit-seeking and therefore the supply of shared B2C vehicles is a reliable indicator of demand.

3.3.8 City policy

City policy is measured by directly asking the largest municipality in a city whether or not they have policy in place for carsharing and whether this policy is designed to be supportive or not. Due to a low response rate (34%, N=60) this variable is not included in the model, but is considered later on for illustrative purposes.

3.4 Data analysis

Analyzing the data is done through descriptive statistics, correlations, a multicollinearity test, and a regression model. This section furthermore elaborates upon the way model fit is assessed as well as how outliers are identified.

3.4.1 Descriptive statistics

The descriptive statistics shed light on the data and its shape. It provides an overview of the distribution of the B2C shared cars among cities and countries.

3.4.2 Correlations

The correlations show any bivariate linear relationship between the dependent variable and the predictor (independent) variable. In order to provide a better picture of the bivariate relationship between these variables, the dependent variable is log-transformed because it is count data. It should be noted that although it is tempting, it is not advised to use a linear regression with log-transformed data as doing so might lead to predicted values substantially lower than those obtained through a Poisson or negative binomial regression (Hilbe, 2014).

Additionally, the correlation matrix is not used as a means to identify multicollinearity. This is because although correlations can show whether two independent variables are correlated, they can only do so for two variables at a time. Multicollinearity is however a problem that can involve multiple variables. This would therefore not provide an adequate impression of the extent of multicollinearity present among the variables.

3.4.3 Multicollinearity test

Prior to being entered into a model, the predictor variables are tested for multicollinearity. This is done by using the collinearity statistics (more specifically the Variance Inflation Factor or VIF) from a linear regression analysis. Even though the coefficients from the linear regression analysis cannot be used to analyze the data, the collinearity values between independent variables are. The VIF is considered to show evidence of significant multicollinearity when VIF >= 5.00 (Rogerson, 2001). The largest values are removed one-by-one until no variable shows evidence of significant multicollinearity.

3.4.4 Regression model

The counts of items in various geographical regions can only take the form of nonnegative integers. Such count data calls for a model based on either the Poisson or the negative binomial probability distribution function (PDF) (Hilbe, 2014). The Poisson PDF is however rarely usable for real data due to its assumption that the mean and the variance are equal (i.e. the Poisson PDF is equidispersed). Real data is almost never equidispersed, which yields a Poisson model useless. Therefore, the most commonly used model that can deal with Poisson overdispersion is the negative binomial distribution. The negative binomial distribution has an additional parameter, the dispersion parameter, which accommodates excess variability (Hilbe, 2014). The data in this study is also Poisson overdispersed, which results in the use of a negative binomial distribution model.

The employed model estimates the dispersion parameter based on a maximum likelihood estimation (MLE). This allows for a more properly fitted model that mitigates overdispersion. Using a Poisson PDF, the model would estimate its standard deviations too liberally as a result of the overdispersion. The negative binomial PDF uses the dispersion parameter to make the estimates more conservative. The default value for the dispersion parameter is set to 1 in SPSS, however its value may differ for each dataset. Setting it to default might make the model too conservative, or not conservative enough. Therefore an MLE approach is used. The model's link function is based on a natural log. This indicates the way that the predictors and the estimated values are expected to be linked.

The data in this study includes another peculiarity: a large amount of observed zeros. To accommodate this high zero count, the negative binomial model is adopted alongside a logit model to form a modeling structure similar to the two-part hurdle model (Hilbe, 2014). It is expected that a "hurdle" needs to be passed for the data generating process to result in positive counts. In the case of this study, first a logit model will be used to get an idea of what might cause the excess zeros to appear. Subsequently, the positive counts are used in a negative binomial distribution regression model in order to gain insight in the process that generates positive counts.

3.4.5 Assessing model fit

Due to some cases missing values for several variables, the amount of valid cases is reduced when a model is generated including variables that are missing case values. When the amount of valid cases drops too low to accommodate the total amount of predictor variables, some predictor variables need to be removed. In order to both improve the fit of the model and accommodate for the maximum amount of variables for the amount of valid cases, variables that are the least significant are removed from the model one-by-one. The improvement in model fit is determined by the difference in Bayesian Information Criterion (BIC) value. A lower BIC value indicates a better fit (Raftery, 1995). Since the BIC value also depends on the total amount of valid cases, N is kept constant until removing another variable no longer improves the model fit. At that point, all valid cases for the remaining variables are entered into the model and further attempts are made to improve the model fit further by removing the least significant variables and looking for an improved BIC value.

In order to determine whether the improvement in BIC value is worth dropping a variable for is determined by using Raftery's (1995) indication of the grades of evidence corresponding to values of the BIC difference (see Table 4.8). The model with the lowest BIC will be selected as most suitable model.

Table 3.3 - Grades of evidence corresponding to values of the BIC difference (Raftery, 1995)

BIC Difference	Evidence
0-2	Weak
2-6	Positive
6-10	Strong
>10	Very strong

3.4.6 Identifying outliers

Outliers are initially identified by plotting the Standardized Deviance Residuals against the predicted shared B2C car count. The resulting plot is expected to have all cases randomly distributed around the vertical axis at X=0. Any points that appear to deviate from this "cloud" of cases are considered potential outliers.

To ensure that there are no cases (outliers) that are highly influential on the model, the value of Cook's distance of all cases is verified. Any values larger than 1 are considered to be highly influential (Cook & Weisberg, 1982). Any cases with such values are omitted from the model and an attempt is made to explain why it is an outlier.

4. Results

The results discussed here are structured as follows. First several descriptive statistics of the data are elaborated upon to get an idea of the data that has been collected. Subsequently the correlations matrix and logit model are briefly discussed. Finally, a regression model to explain the difference in success of carsharing in different cities is discussed and compared with various other regression models.

4.1 Descriptive statistics

4.1.1 Dependent variable

The dependent variable is collected for five (Western) European countries with each containing varying amounts of cities that are eligible for analysis (see Methodology section for the eligible cities). Across these cities a wide spread in the amount of shared B2C cars is observed. Table 4.1 shows the top 20 cities with the most shared B2C cars.

Table 4.1 - Top 20 cities with the most shared B2C cars

Rank	City name	Shared B2C cars	Shared B2C cars per 10000 inhabitants
1	Paris	3956	5.9
2	Berlin	2676	7.8
3	London	1955	2.3
4	München	1589	11.3
5	Hamburg	1449	8.3
6	Amsterdam	1288	12.5
7	Köln	1230	11.9
8	Stuttgart	921	15.2
9	Karlsruhe	666	22.3
10	Frankfurt am Main	654	9.3
11	Düsseldorf	458	7.7
12	Hannover	388	7.5
13	Bruxelles / Brussel	371	3.2
14	Bremen	256	4.7
15	Leipzig	246	4.6
16	Freiburg im Breisgau	244	11.1
17	Lyon	227	1.7
18	Utrecht	216	6.7
19	Dresden	212	4.0
20	Mannheim	190	6.4

The top 20 shows that as expected, larger cities seem to have more shared B2C cars, however there are also several smaller cities that have a high amount of shared B2C cars per capita up in the top 20.

Table 4.2 - Amount of shared B2C cars in various European countries' cities

Shared B2C cars (total)						
	Country					
	België/Belgique (Belgium)	Deutschland (Germany)	France	Nederland (Netherlands)	United Kingdom	Total
Cases	5	53	46	13	60	177
% of total cases	2.8%	29.9%	26.0%	7.3%	33.9%	100.0%
Sum	622	13201	5282	1939	2787	23831
% of total sum	2.6%	55.4%	22.2%	8.1%	11.7%	100.0%
Mean	124.40	249.08	114.83	149.15	46.45	134.64
Median	110.00	66.00	1.50	34.00	3.00	12.00
Minimum	4	0	0	4	0	0
Maximum	371	2676	3956	1288	1955	3956
Skewness	1.651	3.285	6.666	3.397	7.599	5.820
Std. Deviation	145.953	491.197	582.260	348.266	252.174	441.312

When looking at country specific statistics, there are remarkable differences between the success of B2C carsharing between the cities in different countries (see Table 4.2). Where German cities make up roughly 30% of the sample size, they account for a total of 55.4% of total shared B2C cars. France and the United Kingdom make up 26% and 34% of the sample size respectively, however they only account for 22.2% and 11.7% of the total shared B2C cars. Both the Netherlands and Belgium make up a much smaller part of the sample and seem to account for a percentage of the shared B2C cars roughly equal to their share of cities in the sample size.

For all countries, the median is lower than the mean. For four countries, this difference is fairly large, indicating a strong positive skewness. A positive skewness can however be reasonably expected when taking into account that the data is count data[1]. Belgium's median being relatively close to its mean can be explained due to its very small sample size.

Furthermore, there is a total of 33 cities that do not contain any shared B2C cars, the vast majority of which are in France and the United Kingdom (see Table 4.3).

[1] Count data is discussed further in section 3.4.4 on page 32.

Table 4.3 - Amount of cities with zero shared B2C cars in different countries

Country	Cities with no shared B2C cars
Belgium	0
Germany	1
France	21
Netherlands	0
United Kingdom	11
Total	33

When looking more closely at the differences between each country's largest city and the other cities, B2C carsharing appears to have more success in a country's largest city compared to other cities (see Table 4.4). Each largest city is the city with the largest amount of shared B2C cars in their respective country. More specifically, the largest cities represent 2.8% of the total amount of cities, however they account for a staggering 43.2% percent of the total amount of shared B2C cars in the sampled cities.

Table 4.4 - Amount of shared B2C cars in each country's largest city versus in non-largest cities.

Shared B2C cars (total)	Country's largest city		
	Non-largest city	Largest city	Total
Cases	172	5	177
% of total cases	97.2%	2.8%	100.0%
Sum	13585	10246	23831
% of total sum	57.0%	43.0%	100.0%
Mean	78.98	2049.20	134.64
Median	11.00	1955.00	12.00
Minimum	0	371	0
Maximum	1589	3956	3956
Skewness	5.050	.331	5.820
Std. Deviation	216.067	1363.215	441.312

The top three cities are Paris, Berlin, and London: all the largest city in their respective country (see Table 4.1). The other cities that are the largest in their countries are Amsterdam and Brussels, which follow shortly after in sixth and thirteenth position respectively. Four out of five largest cities have a single CSO that controls a majority of the market: Paris and Brussels have over 90% of the market dominated by a single CSO, London 65%, and Amsterdam just over 50%. For Berlin, the largest CSO accounts for 45% of the market.

4.1.2 Independent variables

A total of 23 independent variables (19 variables and 5 country dummies) are considered for the model, however not all variables have complete data for all cases (see. Table 4.5).

Table 4.5 - Independent variable descriptive statistics

	N Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Std. Error	Std. Deviation Statistic
Country	177	0	4	2.40	.098	1.302
City population (tenthousands)	177	15.11	836.25	46.9978	6.53859	86.99033
Population density (pop/km2)	176	264.7	8800.3	1762.967	96.0609	1274.3924
% of population 20-24 years old	177	5.1	17.1	7.719	.1454	1.9348
% of population 25-34 years old	177	10.4	20.9	14.155	.1608	2.1388
% of population 35-44 years old	177	10.9	16.5	13.471	.0787	1.0473
Number of cars per 100 inhabitants	177	25.58	57.38	41.6903	.51482	6.84925
% of one person households	177	24.8	60.8	39.440	.6356	8.4567
% of students in higher education (ISCED level 5-6) in 2011 relative to the city population	143	.12	53.29	8.7897	.53367	6.38175
% of working age population qualified at level 5 or 6 ISCED	171	13.1	60.3	33.376	.7074	9.2500
% of communtes by public transport (rail, metro, bus, tram)	175	4.2	69.4	18.481	.7319	9.6827
% of commutes by car	175	12.9	86.1	61.285	1.0031	13.2700
Historical city	177	0	1	.62	.037	.488
Presence of a university	177	0	1	.47	.038	.500
% of votes in last election for the local Green party	177	0.0	19.8	6.492	.3397	4.5190
Presence of a CSO headquarters	177	0	1	.15	.027	.355
Presence of bikesharing	177	0	1	.53	.038	.500
Herfindahl index of competition (B2C cars)	144	.001	1.000	.75824	.022412	.268940
Carsharing policy	61	0	1	.30	.059	.460

Some other variables have the occasional city missing, but three variables have a large amount of cities missing from their data. The "Percentage of students in higher education" is lacking data for 34 cities, which is a result of the data missing from Eurostat. There is no discernable pattern in this missing data. The "Herfindahl index" statistic is missing data for 33 cities. This is because in cities without a market, there can be no index for the market concentration either. Therefore the 33 cities with zero counts are missing in this statistic. Finally, the "Carsharing policy" is missing data for 112 cities. This is due to a lack of response from the municipalities.

4.2 Correlations

A table of bivariate Pearson correlations between all the variables gives an idea of any potential effects an independent variable may have on the amount of shared B2C cars (see Appendix 3 for a full correlation matrix).

Correlations with the log-transformed[2] amount of shared B2C cars shows that all variables correlate significantly ($p<0.05$) with the dependent variable.

All variables correlate positively with the amount of shared B2C cars except for two. These negatively correlating variables are the amount of registered cars and the Herfindahl index as indicator of competition. This indicates that in cities where car ownership is higher, B2C carsharing tends to be less successful. Also, in cities where there is less competition between B2C CSOs, there are less shared B2C cars. This is in line with what is expected.

One independent variable correlates significantly with the dependent variable with a value over 0.700: the percentage of commutes by car (-.724, $p<0.01$, N=175).

There are four variables that correlate significantly with a value between 0.600 and 0.700. These are the percentage of one-person households (.655, $p<0.01$, N=177), the percentage of commutes by public transit (.655, $p<0.01$, N=175), the presence of a university (.695, $p<0.01$, N=177), and the presence of carsharing policy (.634, $p<0.01$, N=61).

Another four variables correlate significantly with a value between 0.500 and 0.600. These are the population of 25-34 year olds (.597, $p<0.01$, N=177), the percentage higher educated population (.518, $p<0.01$, N=171), the percentage of votes for the green political party (.585, $p<0.01$, N=177), and the presence of bikesharing (.538, $p<0.01$, N=177).

Out of the countries, two countries do not significantly correlate with the dependent variable. These are Belgium and the Netherlands. There are two countries that show a significant and negative correlation with the amount of shared B2C cars, these are France (-.219, $p<0.01$, N=177) and the United Kingdom (-.343, $p<0.01$, N=177). Conversely, there is one country, Germany, that has a significant and positive correlation with the dependent variable (.455,

[2] Cities that contain zero shared cars are assigned a value of zero.

p<0.01, N=177). It appears that cities in France and the United Kingdom have a significantly smaller amount of shared B2C vehicles than German cities.

The correlations so far confirm the hypotheses. In order to get a better insight into what the valuable variables are, a regression model is used.

Between the independent variables, there is a correlation larger than 0.600 between several independent variables. One is the percentage of one-person households and the dummy variables country United Kingdom and country Germany. The correlation values are -.725 (p<0.01, N=177) and .606 (p<0.01, N=177) respectively. This shows that Germany on the one hand contains significantly more one-person households than the other countries, and the United Kingdom on the other hand contains significantly less one-person households than the other countries.

Additionally, the percentage of commutes by car also has a correlation value larger than 0.600 with several other independent variables. These are the percentage of population between 25-34 years old (-.606, p<0.01, N=175), the percentage of one person households (-.638, p<0.01, N=175), the percentage of the population that is highly educated (-.661, p<0.01, N=169), and the percentage of commutes by public transport (-.697, p<0.01, N=175).

There are two more instances where two independent variables correlate stronger than 0.600 with each other. These are policy presence and the percentage of the population between 25-34 years old (.655, p<0.01, N=61) and the amount of registered cars per capita and the country dummy for France (.645, p<0.01, N=177).

4.3 The logit model

In order to arrive at model results, the use of a logit model and a negative binomial regression model are combined. The logit model shows the differences between cities that do and those that don't have any B2C carsharing present.

It appears that French cities are expected to be more likely to have no carsharing available, as well those without a university (see Table 4.6). There are only 22 out of 177 cities the model predicts incorrectly, these are one German city (Herne), ten French cities (Saint-Etienne, Aix-en-Provence, Tours, Angers, Perpignan, Mulhouse, Nîmes, Metz, Cergy-Pontoise, and Avignon) and eleven British cities (Bradford, Belfast, Rotherham, Swansea, Barnsley, Stockton-on-Tees, Basildon, Basingstoke and Deane, Telford and Wrekin, Bedford, and North East Lincolnshire).

Table 4.6 - Logit model: carsharing presence

	Constant only model	Fitted model
Percentage correct	81.4	87.6
Nagelkerke R Square		0.423
Hosmer & Lemeshow Sig.		0.148
N	177	177
Variable	B (Standard Error)	
Constant	1.473 *** (.193)	1.526 *** (.322)
France		-2.090 *** (.472)
University present		2.965 *** (.773)

** Significant at the p<0.05 level. | *** Significant at the p<0.01 level.

The model predicts that French cities without a university most likely don't contain B2C carsharing. Cities that aren't French or contain a university are expected to contain carsharing. This explains why the model cannot predict the German and British cities correctly: they are non-French but don't contain carsharing. The ten French cities is predicts incorrectly are also cities without a university. The model therefore expects them to not have any carsharing present, but they turn out to have it.

4.4 Multicollinearity

With the cities that do contain shared B2C cars, a negative binomial regression analysis is performed. Prior to employing a negative binomial regression model, the variables are analyzed for multicollinearity. As a result, the two variables "Percentage of one-person households" and "Percentage of commutes by car" are removed from the analysis as they show evidence of multicollinearity. The negative binomial regression model is run with the remaining variables.

4.5 The regression model

Several models are analyzed to explain the success of carsharing in European cities. In order to be able to compare these various models they are shown side-by-side in Table 4.7.

4.5.1 Primary regression model results

The first model "Fitted model with max. N" is the model with the best fit with the largest sample size (N=134). It contains twelve variables:

- Four country dummies (and one reference country);
- City population;

- % of the population that is 20-24 years old;
- Registered cars per capita
- % of working age population qualified at level 5 or 6 ISCED;
- % of commutes by public transport (rail, metro, bus, tram);
- Presence of a university;
- % of votes in the last election for the green political party; and
- The Herfindahl index to indicate competition between B2C CSOs.

This means that the following theoretically eligible variables are not included in the model as their contribution to the model was insignificant:

- % of students in higher education (ISCED level 5-6) in 2011 relative to the city population;
- % of the population that is 25-34 years old;
- % of the population that is 35-44 years old;
- Historical city;
- Presence of CSO headquarters;
- Presence of bikesharing programs; and
- Population density.

As expected, this resulting model shows that there is a significant difference between the countries in terms of the success of carsharing in their cities. This confirms hypothesis H.1. Of the cities that contain B2C carsharing, those in the United Kingdom are potentially relatively strongly affected by country-intrinsic variables as all other countries show a significantly stronger coefficient for their country variables (see Table 4.9). This confirms the hypothesis that carsharing success differs between countries and gives strength to the expected presence of a geographical component in transitions as indicated by Hansen & Coenen (2014). Not all countries however have strong differences, Belgium, Germany, and the Netherlands all have a relatively similar coefficient when compared to the United Kingdom. This indicates that any potential intrinsic country variables for these three countries amount to the same effect on the success of B2C carsharing. A final interesting result between the countries that emerges from the model is that the French cities that do contain B2C carsharing have a very large amount of cars. This could however potentially be skewed by the relatively huge amount of shared B2C cars in Paris.

A larger city is also expected to contain a larger amount of shared B2C cars, confirming hypothesis H.8. It is however not a very strong relationship. This shows that the success of carsharing is not necessarily strongly linked just to the size of a city. The other variables seem to have a stronger effect on the B2C carsharing level of service and therefore appear to be more important to explain it.

An unexpected result is that population density is not a significant variable in explaining the amount of shared B2C cars. Hypothesis H.2 can therefore not be confirmed. This is in contrast to the results obtained by Meelen et al. (forthcoming) who studied carsharing at the municipal level in the Netherlands. However, Celsor & Millard-Ball (2007) in turn did not find that residential density stood out in American neighborhoods as explanatory variable for the B2C carsharing level of service. When taking a closer look at the studies and what role population density might play when trying to explain the success of B2C carsharing the lack of a significant effect becomes clear. The difference between the study by Meelen et al. and this study as well as the study by Celsor & Millard-Ball is that Meelen et al. (forthcoming) look at neighborhoods throughout the Netherlands. This includes low density neighborhoods and high density (city) neighborhoods. Celsor & Millard-Ball (2007) as well as this study look at (neighborhoods within) cities, which are apparently already sufficiently high density areas for carsharing to take place. This insinuates that the success of carsharing is likely no longer dependent on population density after a certain threshold. This threshold is expected to be lower than the typical population density encountered in European cities.

The relative size of the younger population group in the city appears to be a significant explanatory variable only for the population 20-24 year olds. The effect is however negative. Hypothesis H.9 can therefore not be confirmed. A potential explanation for this could be that since the variable of university presence is included in the model, it interferes with the age variable. The variables correlate significantly ($p<0.01$, $N=177$) with a value of 0.441. Another potential explanation could be that the population between 20-24 years old don't all have a driver's license yet. Since the data is from 2012 and 2013, this population group was between 16 and 21 at the time that the 2008 financial crisis hit. Around this age is when people can start to get their driver's license. It could be that this age group postponed getting a driver's license as the lessons and driving test are relatively large expenses and they did not have the financial means at the time due to the crisis. Meelen et al. (forthcoming) observed a positive effect for age groups between 25-45 and 45-65 on B2C carsharing. In this study, the age groups 25-34 and 35-44 did not appear to be population groups that explained the success of B2C carsharing at the city level however.

Another significant variable is the amount of total registered cars, indicating that a higher car ownership leads to a lower expected shared B2C car count as expected. Hypothesis H.3 can therefore be confirmed. This result indicates that the car ownership regime is significantly weaker in those cities where more B2C carsharing is present. This is in line with the results obtained by Celsor & Millard-Ball (2007) who found that neighborhoods with a high level of service for B2C carsharing had a higher amount of households with no cars or one car.

The proportion of higher educated inhabitants is indicated to be a variable that would increase the expected count of shared B2C cars when the proportion is higher. As such, hypothesis H.10 can be confirmed. This finding is in line with the expectations that come from Rogers's (1962) theories on the adoption of innovations where higher educated people tend to be more willing to adopt innovations. It is also to some extent in line with the results obtained by Meelen et al. (forthcoming) and Burkhardt & Millard-Ball (2006) as they observed a similar relationship.

Also as expected, an increased use of public transit in a city leads to believe that the amount of shared B2C cars in that city would be higher. Hypothesis H.5 can therefore be confirmed. This is in line with the expectations that a successful public transit system weakens the car ownership regime, giving more room for the success of carsharing. This result agrees to some extent with that of Celsor & Millard-Ball (2007) who found that even though for most regions transit commute mode share correlated positively with the B2C carsharing level of service. In their study it however did not significantly correlate for all regions they investigated.

The percentage of votes for the local Green party also appears as a significant variable. For a single percentage point increase in the amount of votes for the Green political party, the expected shared B2C car count goes up by 10.6%. Hypothesis H.12 is thereby confirmed. This is in line with earlier research by Meelen et al. (forthcoming), where the environmental party votes variable was also found to have a strong positive effect on the B2C carsharing level of service.

With regards to student presence, the relative amount of students does not appear to be of significant explanatory power, but the presence of a university is. Hypothesis H.13 can therefore not be confirmed, but H.6 can. Millard-Ball et al. (2005) also indicate that university campuses are "fertile environments" for carsharing. Nevertheless, the role of students in relation to B2C carsharing remains inconclusive. It may be more nuanced than simply grouping all students in higher education. The difference in significance between the amount of students and university presence may be due to the structure in the education system. In the Netherlands for example, the three levels of post-secondary education (MBO, HBO, and WO) each have their own institutes for education. Universities only provide academic-level post-secondary education (WO), while the number of students includes both higher-level (HBO), and academic-level (WO) post-secondary education. Nevertheless, since the presence of universities seems to be explanatory for both the presence and the success of B2C carsharing, the insignificance of the student population and significant, but negative, explanatory power of the 20-24 year old age group variable are interesting to say the least.

Historical city status as a proxy for urban form does not yield any significant addition to the model. Neither do the presence of bikesharing, and the presence of a CSO headquarters. This means that hypotheses H.7, H.14, and H.15 cannot be confirmed.

The Herfindahl index of market concentration as a proxy for B2C competition does have a significant addition to the model. This shows that in cities with more concentrated markets, the amount of shared cars is expected to be lower. Hypothesis H.16 can therefore be confirmed. A potential side-note here is that swallowing a small market is relatively easily done by a small, local CSO. A larger market on the other hand allows for more small CSOs to start in the market, compete with each other, and potentially grow over time. If this is the case, then you would also expect smaller markets (and thus smaller cities) to have less competition than bigger cities.

Table 4.7 – Summary of the results

	Construct	Hypothesis	Effect*	Hypothesis confirmed?
Regime features	Country level differences	H.1	Mixed	Yes
	Population density	H.2[1]		No
	Car ownership	H.3	-	Yes
	Modal split favoring public transit	H.4[2]		No
		H.5	+	Yes
	Presence of students	H.6	+	Yes
	Urban form	H.7[1]		No
Niche Features	City population	H.8[1]		No
	Young population	H.9	Mixed	No
	Education level	H.10	+	Yes
	One person households	H.11[2]		No
	Sustainability awareness	H.12	+	Yes
	Presence of students	H.13[1]		No
	Acquainted with sharing economy	H.14[1]		No
	History of carsharing	H.15[1]		No
	Competition among CSOs	H.16	+	Yes
	City policy	H.17[1]		No

* A "-" indicates a negative effect, a "+" indicates a positive effect, and "Mixed" indicates there were multiple variables that had varying effects and/or significancies.

1. Variable related to construct showed no significant effect.
2. Variable related to construct was omitted from the analysis due to multicollinearity.

4.5.2 Additional models

The "Full model" in Table 4.8 is the model containing all possible variables with N=114 due to several variables limiting the amount of valid cases. Therefore a third model to compare the fit with the full model is shown, the "Fitted model with full model N". This model uses the N of the full model in order to be able to compare the fitted model with the full model. When comparing the BIC and AIC values of these models, it becomes apparent that the fitted model (with a BIC of 1277.0) better explains the data than the full model (BIC of 1176.6). A fourth model "Fitted model incl. Policy" added the variable "Policy presence" to the fitted model in order to assess whether it contributes explanatory power to the model. The variable is however not a significant contributor to the model ($p>0.1$, N=51). When comparing the goodness-of-fit indicators of this model (BIC 440.9) with the fifth model "Fitted model with policy model N" (BIC 437.1), the BIC and AIC values indicate that adding the policy variable does not improve the model. However with such a low sample size, the results of the fourth and fifth model can at most be considered suggestive, as such a low amount of variables per predictor could make the coefficients unstable.

Table 4.8 - Comparison of different models used

Model	Fitted model with max. N	Full model	Fitted model with full model N	Fitted model incl. Policy	Fitted model with policy model N
AIC	1236.0	1119.2	1111.9	411.9	410.1
BIC	1277.0	1176.6	1150.2	440.9	437.1
Pearson chi^2/df	1.197	1.286	1.195	1.485	1.449
N	138	114	114	51	51
Variable	B (Standard Error)				
Constant	3.999 *** (1.101)	2.028 (2.090)	4.268 *** (1.173)	4.645 *** (1.578)	4.465 *** (1.529)
Belgium	1.105 *** (.3935)	.715 (.4794)	.922 ** (.4227)	1.673 *** (.4962)	1.651 *** (.4973)
Germany	1.126 *** (.2387)	.955 *** (.3511)	1.057 *** (.2727)	.922 ** (.4050)	.953 ** (.4022)
France	1.716 *** (.3202)	1.363 *** (.4048)	1.548 *** (.3646)	2.071 *** (.5697)	1.997 *** (.5466)
The Netherlands	1.066 *** (.2699)	.795 ** (.3606)	0.896 *** (.2976)	1.549 *** (.3317)	1.517 *** (.3241)
The United Kingdom	0[a]	0[a]	0[a]	0[a]	0[a]
City population	.003 * (.0017)	.004 ** (.0021)	.004 * (.0024)	.014 *** (.0053)	.014 ** (.0053)
Population density		.000 (.0001)			
% age 20-24	-.145 ** (.0465)	-.150 ** (.0692)	-.162 *** (.0481)	-.128 * (.0738)	-.119 * (.0702)
% age 25-34		.079 (.0643)			
% age 35-44		.081 (.1209)			
Cars per 100 inhabitants	-.080 *** (.0203)	-.068 *** (.0232)	-.080 *** (.0221)	-.074 *** (.0277)	-.070 *** (.0266)
% highly educated population	.054 *** (.0114)	.041 *** (.0139)	.052 *** (.0124)	.030 ** (.0152)	.030 * (.0153)
% communtes by public transport	.032 ** (.0141)	.025 (.0184)	.027 (.0164)	.026 (.0232)	.028 (.0231)
% of votes for the Green party	.101 *** (.0252)	.089 *** (.0271)	.095 *** (.0262)	.172 *** (.0451)	.161 *** (.0374)
Students in higher education		-.009 (.0125)			
University presence	.716 *** (.1782)	.759 *** (.1962)	.760 *** (.1914)	.163 (.2420)	.159 (.2420)
Historical city		.240 (.1885)			
Bikesharing presence		.105 (.2064)			
CSO HQ presence		.179 (.2058)			
Herfindahl index (B2C)	-.970 *** (.2871)	-.817 ** (.3295)	-.815 *** (.3076)	-1.776 *** (.4898)	-1.784 *** (.4899)
Carsharing policy				-.101 (.2347)	

a. Set to zero because this parameter is redundant.
* Significant at the p<0.1 level. | ** Significant at the p<0.05 level. | *** Significant at the p<0.01 level.

The variable "Policy presence" has a minor negative, but insignificant, effect on the B2C carsharing level of service. This means that hypothesis H.17 cannot be confirmed. Previous research by Meelen et al. (forthcoming) indicated that policy may significantly contribute to estimating an expected amount of shared B2C cars in a geographical area. Their result is strengthened by previous research that also mentions the importance of policy for the success of carsharing (Shaheen et al., 2010). Results of this research indicates however that policy may not necessarily be required for B2C carsharing to be successful. The relationship between policy and the success of carsharing does not appear to be causal, i.e. policy does not seem to be a prerequisite for carsharing to become more successful.

Table 4.9 - Percentage change in expected B2C carsharing level of service in a city (country values are relative to the baseline country: the United Kingdom)

Fitted model with max. N		
	Increase compared to the UK	
Belgium	202%	
Germany	208%	
France	456%	
The Netherlands	190%	
	Increase compared to cities without university	
University presence	105%	
	Per unit increase	Per S.D. Increase
City population (tenthousands)	0.3%	29%
% age 20-24	-13.5%	-27%
Cars per 100 inhabitants	-7.7%	-50%
% highly educated population	5.5%	51%
% communtes by public transport	3.3%	32%
% of votes for the Green party	10.6%	47%
Herfindahl index (B2C)	-62.1%	-17%

4.4.3 Residual analysis

Figure 4.1 shows the predicted value plotted against the standardized deviance residual for the "Fitted model with max. N". Ideally the distribution of the residuals among positive and negative residuals is equal. This is mostly the case apart from a slightly discernable curve in the bottom left of the graph that has low predicted mean values and has negative standardized deviance residuals. These are the cities that currently have one or two shared B2C cars.

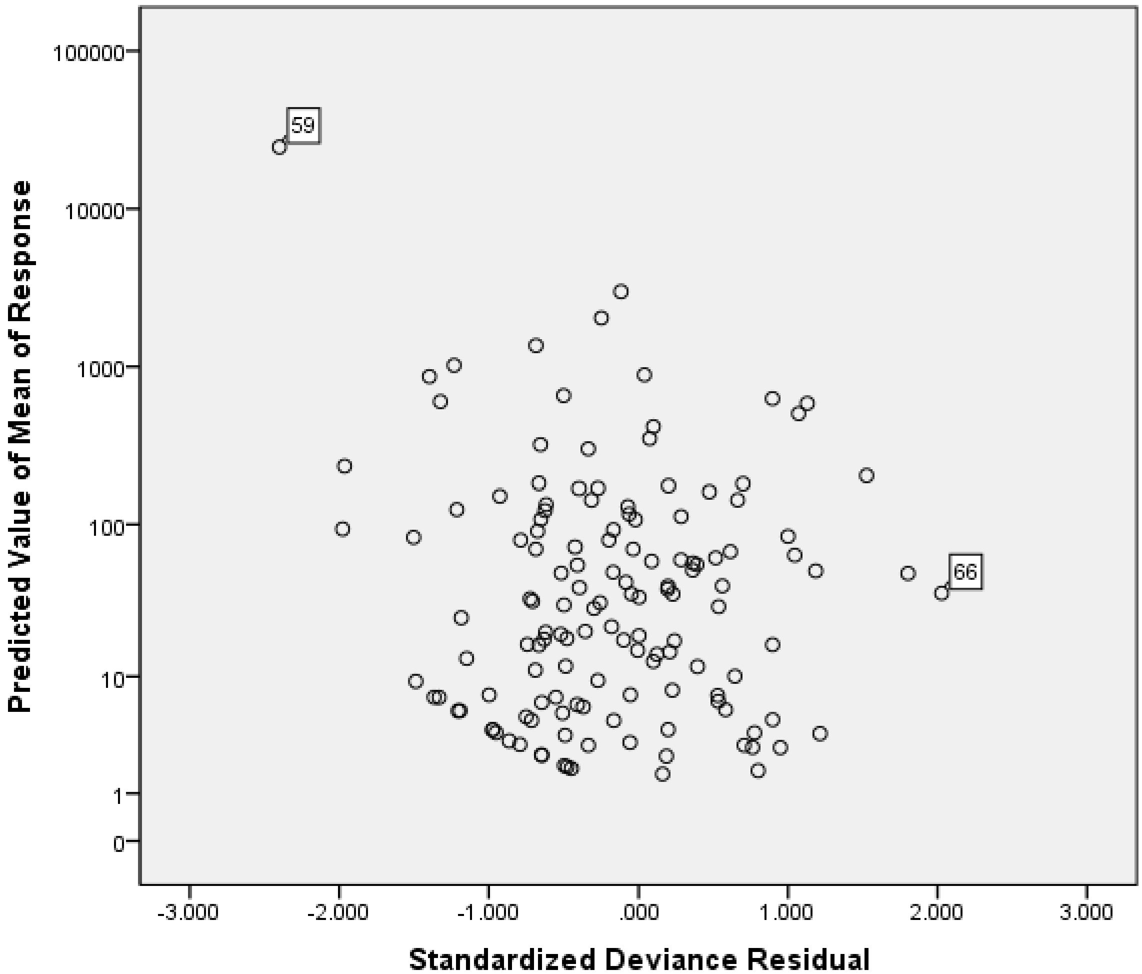

Figure 4.1 - The predicted value plotted against the standardized deviance residual (59=Paris, 66=Nice)

Two cases have a Standardized Deviance Residual over 2.0: the French cities of Paris and Nice. The reasons as to why this is the case are as follows:

- Paris: France's capital's population is very large, as well as the percentage of commuters using public transit and the amount of higher educated people. It also contains a university and has a noticeably low percentage of 20-24 year olds and cars per capita. The green vote percentage is only slightly larger than the French mean, and the competition is almost equal to the French mean. Apart from these last two variables, all the other variables are favorable for a high level of service. Paris has over 34 times the amount of shared cars as the average French city, but its demographics and other statistics makes the model expect an even higher amount.

- Nice: The city of Nice has a level of service some 30% higher than the French mean. However, many statistics point at nice being a fairly average city. One statistic that is relatively far from the average is the percentage of 20-24 year olds, which is about 25% lower than the French mean. Other than that, its population is only slightly higher than the average, the cars per capita slightly lower, the amount of market concentration slightly higher, and the city contains a university. There is one more statistic however that would make the model expect Nice to have a much lower level of service than it actually does, which is the percentage of votes for the green party. In the case of Nice, it appears that there was no-one electable of the French green party "Europe-Ecologie-Les Verts", hence the percentage of votes for the green party is zero.

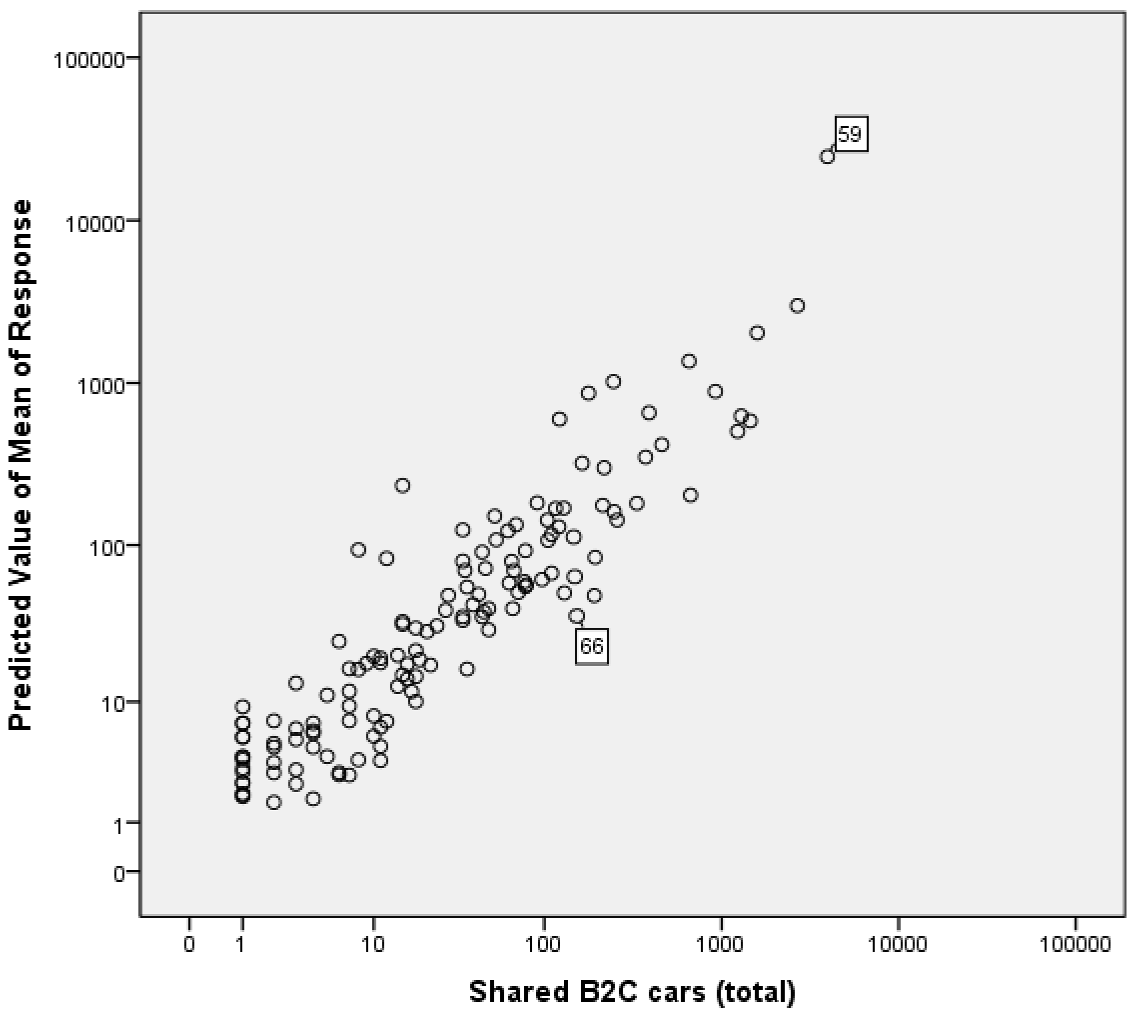

Figure 4.2 - The predicted value plotted against the observed value (59=Paris, 66=Nice)

Figure 4.2 plots the predicted value against the observed value. The model's expected amount of shared B2C cars in a city fairly closely matches the observed count even when including the outliers. When looking at the maximum Cook's distance, these outliers are not indicated to influence the model significantly. The maximum Cook's Distance of 0.688 is well below 1.00, indicating that even the farthest outlier has no strong effects on the model (Cook & Weisberg, 1982).

4.6 Bikesharing logit model

An interesting additional analysis that can be performed using the available data is a logit model using the presence of bikesharing as a dependent variable. A relatively strong improvement over a constant-only model is obtained using only one independent variable: a dummy variable for the UK (see Table 4.10). Taking into account that one-person households exhibit multicollinearity with the country variable, using the Percentage of one-person households as independent variable also yields a model that explains a majority of the cases.

In case UK cities may have a particular mechanism blocking the roll-out of bikesharing initiatives, they are filtered out of the database for further analysis of the other cities. However, from the remaining cities no clear explanatory variable(s) can be identified.

This shows that the presence of bikesharing can be strongly country-dependent and that there is no common (demographic) city data that seems to be able to explain the emergence of bikeshare programs in different cities.

Table 4.10 - Bikeshare logit model: the constant only model compared to the fitted model.

Bikeshare Logit model	Constant only model	Fitted model 1	Fitted model 2
Percentage correct	53.1	75.7	76.3
Nagelkerke R Square		0.337	0.414
N	177	177	177
Predictors	B (Standard Error)		
Constant	.124 (.151)	.934 *** (.205)	-6.899 *** (1.067)
Dummy UK		-2.544 *** (.403)	
% of one-person households			.180 *** (.027)

** Significant at the p<0.05 level. | *** Significant at the p<0.01 level.

5. Conclusion

This research set out to answer the question to what explains the differential adoption of B2C carsharing across European cities. Several indicators were identified that theoretically would weaken the regime or strengthen the niche. These indicators were therefore expected to have a positive effect on the amount of shared B2C vehicles in cities. Resulting from the negative binomial regression model, the most relevant indicators are the country in which the city is situated, the city size in terms of its population, the level of car ownership, the education level of the city's inhabitants, the city's modal split, the city population's awareness of sustainability, the competition between B2C CSOs, and to some extent the presence of students.

The differences between countries amounted to a strong factor when explaining the success of B2C carsharing in cities, indicating the potential effect of national culture, policy, or other differences at the national level. Currently, the country effect is positive in Belgium, Germany, France, and the Netherlands when compared to the United Kingdom. The strongest explanatory continuous variable is the sustainability awareness of the population, an indicator which is measured through the amount of votes for the green political party.

An additional insight appeared in the role of population density. Population density, while expected to be an influential variable in determining the success of B2C carsharing, appeared to not contribute significantly to the model. This is evidence for population density only being important up until a certain threshold. When this threshold of population density is reached, it is no longer an important variable in explaining the success of B2C carsharing. As cities have high population densities by definition, the sample's minimum population density may already exceed this threshold.

The research added to the existing literature the importance of the differences between countries to explain the B2C carsharing level of service at the city level. Additionally, it further reinforced the importance of sustainability awareness among the potential users to explain the success of B2C carsharing.

Within the innovation literature it further reinforced the geographical nature of transitions. Where the geographical nature of transitions was not clearly defined at the conception of transitions literature, recently more evidence has emerged that transitions happen in a geographical context. Previous research has frequently highlighted the influence of differences in local policy, institutions, natural resources, knowledge spillovers, and markets as the geographical influences on sustainability transitions. This research added to the theory that local advantages for the carsharing niche market and local restrictions for private car ownership influenced the success of the niche vis-à-vis the regime. Such local differences do not only manifest itself at the national level, but also at the city level differences in local features influence the success of the niche.

The results of this study can be used to identify potential cities where B2C carsharing could be a success. This is of interest to both policy makers who are debating the effectiveness of B2C carsharing in their city and to B2C carsharing firms who are looking to expand to new cities.

Future research can provide deeper insights in the role of policy in the success of B2C carsharing. Additionally, a larger sample of cities can be analyzed in order to determine whether the constructs that were determined to be influential in determining the success of carsharing in a city are similarly influential across a wider range of countries.

6. Discussion

During the research, several issues came up that introduced limitations to the research. These will be addressed in the following paragraphs as well as reflections on the theory used.

6.1 Theoretical reflection

This research highlighted the usefulness of the multi-level perspective, an inherently non-geographical theory, for the analysis of spatial differences in sustainability transitions. Such insights have been uncovered previously (Hansen & Coenen, 2014), but this research added some nuances in the interpretation of these previous results.

One of these is the apparent importance of policy. With the large amount of research into the importance of policy in transitions, it seems like policy is at least one of the most important sources of spatial differences. This was however not necessarily the case for this research. On the contrary, the role of consumers and local market formation seems to be only marginally researched, whereas the local market characteristics seemed to be adequately able to estimate the success of the niche in a geographical region. It appears that not all researched themes identified as influencing the geographical context of sustainability transitions (see Hansen & Coenen, 2014) are applicable to sustainability transitions.

Furthermore, the use of the multi-level perspective and its interpretation in terms of local regime versus niche strength proved to be useful in the analysis of spatial differences in transitions. However, it appeared to be more complex translating the notion of the landscape to a more local interpretation. This research assumed the landscape to be universal across all cities, but landscape events, such as war and economical crises for example, are not ubiquitous and also have spatial limitations. For the purposes of this research, assuming the landscape to be constant across all cities that were studied is not expected to have significant effects on the results of the research as all cities physically lie relatively close to each other. When studying various cities that lie farther away from each other however, the landscape may play a more prominent role in explaining geographical differences in transitions.

6.2 Zero Counts

Ideally, when assuming that the success of B2C carsharing is indicated by the level of service, the zero counts represent cities where carsharing is not viable. However, it is unsure whether the lack of B2C shared cars exists because it was tried and was discontinued (which would truly indicate that B2C carsharing doesn't work in the city), or whether B2C carsharing has simply never been introduced to the city yet (and it might be very successful if it was). This may be an interesting statistic to collect since assuming that zero counts are cities where carsharing is unsuccessful may be a premature one. Especially since the amount of zero counts is relatively high, falsely assuming that a zero count indicates that carsharing is not successful in that city may severely impact the outcome of the research. This research dealt with this problem by only applying the model that estimates the success of B2C carsharing to those cities that have a positive count for B2C carsharing. Future research would be able to get more accurate results when they can differentiate between "good" zeroes (those that resulted from the discontinuance of B2C carsharing because it was unsuccessful) and "bad" zeroes (those that are a result of B2C carsharing never having been introduced to the city).

6.3 Supply indicating demand

The previous issue is also linked to the use of the level of service as indicator for B2C carsharing success as a whole. When a B2C CSO introduces a fleet to a city, it takes time to settle on the optimal amount of vehicles that the people in this city uses. If a CSO has had their fleet operational for long enough to settle on this amount, the total amount of counted B2C shared cars might not represent the relative success of carsharing in the city. In the worst case scenario, it might even be the case that a CSO enthusiastically introduced a fleet of several hundred vehicles, when it turns out that very little people use it. The odds of such an extreme case happening are expected to be very low however, as such a scenario would incur heavy financial losses for the CSO. It is expected that a CSO operates a trial fleet prior to launching to the full public in order to gauge interest in the service. The fleet size of the public launch might be very dependent on how successful such a trial is. Since cities vary in their characteristics, it can take longer or shorter in different cities for the level of service to settle on an amount of cars that relatively accurately reflects the success of B2C carsharing. Even when it has, a city's characteristics are ever changing, meaning that the level of service is as well. It is currently unknown whether the B2C carsharing market has settled enough in every city in order to determine the exact reliability of the level of service as indicator for B2C carsharing success. On the one hand, continued research on the relationship between cities and carsharing success can consider to add a parameter to correct for the length of time a CSO has been present in the city. On the other hand, further research into the history and growth/decline of carsharing in various cities may provide insights into what factors indicate that the level of service has reasonably settled and thus can be accurately used as an indicator for B2C carsharing success.

6.4 Negative Binomial: Zero-Inflated or not?

A further limitation concerns the use of the specific regression models. Over twenty percent of the dependent variable are zero counts. It was therefore preferred to use a Zero-Inflated Negative Binomial (ZINB) regression model is preferred in order to adjust the analysis for the excess zeroes. It expects two different processes that generate the outcome: one process that generates zero counts, and another that generates "actual" counts. It therefore processes the data by running two models in one algorithm: a logit model and a negative binomial model. However, since the main statistics program SPSS used for this study was unable to perform a ZINB, the preference shifted towards a hurdle model. A two part hurdle model approaches the data in a similar way as the ZINB, using two steps in the model: one logit and one negative binomial or poisson-based model. The difference is that step containing the negative binomial or poisson-based model does not allow for zero counts: a zero-truncated negative binomial should be used. SPSS however also does not provide a way to run zero-truncated or hurdle models. The final models were therefore generated using a separate logit model, and then a negative binomial using only the positive counts. This is neither a complete zero-inflated, nor a hurdle model. The impact of this compromise is regarded as non-influential on the results of the research. This is because the mean of the count data is 132 in this study, and in practice the difference between a zero-truncated and a regular negative binomial is negligible when "the mean of the count response variable is high - perhaps over 4" (Hilbe, 2014; p. 177). It is however recommended that future research takes into account the possibility of having to run a zero-inflated or hurdle model and select their statistical analysis software accordingly.

6.5 Observations per predictor variable

Another model-related limitation of the research is the amount of observations (or events) per predictor. Various rules-of-thumb are used for modeling, but one that is frequently used is 10 events per predictor variable (EPV) (Vittinghof & McCulloch, 2007). The final model in this research contains 134 "events" and 11 predictor variables. The research is therefore in-line with the rule of thumb. This accuracy of this rule-of-thumb has however been questioned several times (Vittinghof & McCulloch, 2007; Van der Ploeg et al., 2014). These studies indicated that such a rule-of-thumb is not a clear threshold and that even though accuracy of the results increases as the EPV increases, the frequency of problems varies among different studies. Van der Ploeg et al. (2014) indicate that for medical prediction problems the EPV needs to be more than 10. Vittinghof & McCulloch (2007) mention that for Cox and logistic models problems are "uncommon" at an EPV between 5 and 9, but problems "are still observed" at an EPV between 10 and 16. When taking into account that these studies focus on applications of these models in a medical context where margins of error are extremely small, having an EPV of 12.2 is considered to be sufficient for the purposes of this research where only insights into the relationship between demographic and other variables is desired.

For further research to be sure to have enough observations, the amount of cities counted can be increased by either adding more countries or adding cities below 150,000 inhabitants.

6.6 Completeness of dependent variable data

Although extensive efforts have been made over a period of two months to collect all possible B2C CSOs in the five countries being analyzed, it is always possible that some have not been found. This would imply that the database of the count of shared B2C cars is inaccurate to an unknown extent. It is however expected that any potentially missing data does not severely impact the results of the research as it is highly unlikely that CSOs with large fleets have been missed during the collection process. Attempts were made to use aggregators of CSOs (e.g. Bundesverband CarSharing) in order to find all CSOs that exist in a particular region, however these are not always complete as further research through online search engines provided CSOs that were not included in the lists provided by such aggregators. Future research can benefit from improved the data reliability if a method is identified to ensure that all CSOs and their active locations are known.

6.7 Missing data

There are several known cases where the cars of the CSO were not included in the final count of shared B2C cars. One is a small CSO in Germany called App2drive. It is known that the CSO is small due to its business model (station-based) combined with the limited amount of stations mentioned on their website. Unfortunately they didn't provide any information on the amount of shared B2C cars they have and thus it was impossible to know the exact amount of cars in their fleet. Several other known cases are those of several French CSOs. The existence of these CSOs was not known until after the research was conducted. The size of the CSOs is not known exactly as they don't provide exact counts of cars on their websites. However, one is known to have over 200 vehicles and another just over 10, indicating that these are not only small CSOs. They cover several cities that were initially thought to not contain any shared B2C cars. Would this data have been available during the time of the research, the results could look very different especially for the French country variable.

6.8 Standardized indicators for city services and quality of life

A suggestion for future research would be to look into the availability of more centralized city data. One source for such data could in the future potentially be from ISO 37120. This is a collection of standardized indicators set by the International Organization for Standardization for "Indicators for city services and quality of life" (ISO, 2014). Data is being collected and distributed online by the Global Cities Institute (http://cityindicators.org/) and the World Council on City Data (http://www.dataforcities.org/). The websites work through application of the cities themselves however, and as of yet they are not being used by many cities yet. If the ISO 37120 standard becomes more widespread, it may be a valuable and reliable source of comparable city-level data.

6.9 Ecological Fallacy revisited

Even though care is taken to use as much data based on distributions rather than means, the availability of such data is not very high. As a result only age distribution and education level is taken into account, however more distributional data on car ownership and income would also be very interesting to look at if it were available. Lacking income data and having used a mean statistic for car ownership data means that the results may be more nuanced than they seem as a result of this research. Car ownership may not necessarily need a low amount of cars per capita, but potentially a larger group of households that don't own a car at all. Future research should definitely attempt to use distributional data over data based on means whenever possible.

6.10 The effect of policy on carsharing

In the literature on (sustainability) transitions, the effect of local policy is often highlighted as a reason for geographical differences in the transition process. This study thus tried to gauge the effect of policy on B2C carsharing at a city level. Due to an insufficiently large sample size the study was unable to provide any insights into the effect of policy on carsharing. However, based on the responses that were received from the municipalities on the presence of carsharing, many indicated that they were working on developing legislation and/or cooperating with B2C CSOs. This shows that currently a lot of development is going in the field of policy, with many municipalities trying to develop policy that fits their needs.

So many different types of policy may therefore not be comparable to one-another in terms of their support for carsharing. Presumably, Meelen et al. (forthcoming) therefore used a tiered policy indicator where the policy variable could take three distinct values instead of being a binary variable. This could accommodate some of the variance in policy, however even then one must be careful with policy that is well-meant to have an adverse effect. For example, potential policy supporting (or collaboration with) a specific CSO may raise the barriers of entry to that market for different CSOs, hampering competition and potentially stunting growth of carsharing in that market.

A quantitative study might therefore not be the most useful at this point in time to study the interaction between policy and carsharing success. A qualitative approach focusing on developed applications of carsharing policy at the city level may yield more insight into what types of policy and collaboration between local government and CSOs have been the most effective to stimulate carsharing.

6.11 Additional indicators

There are numerous suggestions for additional indicators that can be potentially useful in future studies on the relationship between B2C carsharing and cities. These were not used in this study due to difficulties operationalizing the variables.

6.11.1 City "tech" level

A city's tech level may come in the shape of how familiar the population is with new technology (preferably relevant technology such as smart phones or apps). The preference would of course be to have distributional data rather than a mean.

6.11.2 City culture

Culture is not necessarily a country variable, as culture has historically transcended contemporary political boundaries and still does. Different cultural perceptions of car ownership, car use, and sharing may also be able to shed light on the differences between the various B2C carsharing levels of service among cities.

6.11.3 Cost of car ownership

The cost of car ownership may have an impact on the propensity of a citizen to own a private car. Without access to a private car, they would be more inclined to use carsharing when a situation arises where using a car would be very beneficial. Costs of car ownership are generally dictated by national policy, however also local context may affect the cost of car ownership. One way would be through parking costs (the more expensive it is to park your car, the less people can afford one).

6.11.4 Income distribution

Those that cannot afford private vehicle ownership, but do desire the freedom of transportation that private vehicle ownership yields may turn to carsharing as an affordable alternative. In other words, economists may argue that carsharing is an inferior good that may be consumed most by low income households. Therefore it is expected that carsharing is more successful in cities that contain a large share of households with an income lower than the country's median income. Additionally, higher income population groups have been shown to be more willing to adopt innovations earlier (Rogers, 1962). Previous research in the relationship between carsharing and income distribution yielded mixed results. Burkhardt & Millard-Ball (2006) found that a large amount of participants in carsharing were in a higher income group, but Coll et al. (2014) in the meanwhile found a negative effect between high income and the participation in carsharing. Meelen et al. (forthcoming) did not find a significant effect between the success of B2C carsharing and the average income in a neighborhood. These contrasting findings warrant further efforts to clarify what the role of income is when trying to explain the success of carsharing.

6.11.5 Exposure of carsharing to the city population

The more people know about carsharing, the higher the chance that people who would be interested in adopting such a service actually did. A difficulty with such a variable is that it could be difficult to quantify exposure to a service.

One way could be to look at the length of time that carsharing has been present in a city since the longer carsharing has been present, the higher the chance that people have been exposed to the service.

Another way could be to look at local newspaper articles about carsharing and whether the articles were positive or negative. Combined with the market penetration of the local newspaper, it could be possible to quantify the extent to which the local population was exposed to carsharing and whether this exposure is expected to benefit carsharing.

6.11.6 Interaction effects between variables

This study did not take any possible interaction effects between variables into consideration. A regression analysis may however be subject to interaction effects occurring between independent variables. Controlling the model for interaction effects could potentially improve the results.

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308,310,312,318,320-321,323-324,326,334-336,339-343,347,352,356-357,361,364,366,369,373,377,380,382-384,386,388,396,399,405-406,410,413,415-419,423,427-430,432,436,442-443,445-446,448,450,454,457,461-464,467,469,473,478-479,481-483,488-489,496-497,501,506-507,510,512,519,524,526,528-529,532,542-543,545,549-550,553-556,558,560-562,566,568-571,573,576,578-579,590-591,594,597-598,600,602-604,614-615,617-618,625-626,628,632,637-639,642,645-646,654,656,661,664-665,667,669,673-674,677,680,685,690,702-704,707,709,711-713,716,719-720,725,728-731,735,737-740,746,748,750,755,757-758,764-765,770,773,776,778-779,781,784,789,791,793,799-801,803-805,807,812,816,818,821-822,826-827,832,834-835,842,848-851,853,860,863-864,870-871,873,877-878,880,883,887-889,895,897,899,901,904,906,908,912-913,919-920,922-924,926,929-931,933-934,937,939-940,945,950-952,955,958,961-966,968-969,971,975-976,979,981,984,988-989,993,995-996,998-999,1008,1010,1012-1013,1015,1018,1024-1025,1027,1029-1030,1033,1036-1037,1041,1050-1051,1055-1056,1058,1062,1065-1066,1073-1074,1076-1077,1079-1080,1082,1084,1092-1093,1095,1098,1100-1101,1104,1107-1108&D4=l&HD=150914-1447&HDR=T&STB=G2,G3,G1.

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9. Appendices

Appendix 1 - Eligible cities

Belgium	2013
Bruxelles / Brussel	1,174,624
Antwerpen	512,230
Gent	249,754
Charleroi	204,826
Liège	382,009

Germany	2014
Berlin	3,421,829
Hamburg	1,746,342
München	1,407,836
Köln	1,034,175
Frankfurt am Main	701,350
Stuttgart	604,297
Düsseldorf	598,686
Dortmund	575,944
Essen	569,884
Bremen	548,547
Leipzig	531,562
Dresden	530,754
Hannover	518,386
Nürnberg	498,876
Duisburg	486,855
Bochum	361,734
Wuppertal	343,488
Bielefeld	328,864
Bonn	311,287
Münster	299,708
Karlsruhe	299,103
Mannheim	296,690
Augsburg	276,542
Wiesbaden	273,871

Gelsenkirchen	257,850
Mönchengladbach	255,430
Braunschweig	247,227
Chemnitz	242,022
Aachen	241,683
Kiel	241,533
Halle an der Saale	231,565
Magdeburg	231,021
Krefeld	222,058
Freiburg im Breisgau	220,286
Lübeck	212,958
Oberhausen	209,097
Erfurt	204,880
Mainz	204,268
Rostock	203,431
Kassel	194,087
Hagen	185,996
Saarbrücken	177,201
Hamm	176,048
Mülheim a.d.Ruhr	166,640
Ludwigshafen am Rhein	161,518
Potsdam	161,468
Leverkusen	160,819
Oldenburg (Oldenburg)	159,610
Osnabrück	156,315
Solingen	155,768
Herne	154,417
Heidelberg	152,113
Neuss	151,070

France	**2012**
Paris (greater city)	6,707,750
Lyon	1,321,495
Lille	1,119,832
Marseille	1,045,805

Bordeaux	730,116
Toulouse	725,052
Nantes	602,853
Nice	520,990
Rouen	488,706
Strasbourg	473,495
Montpellier	434,189
Toulon	425,609
Rennes	408,428
Grenoble	405,156
Saint-Etienne	374,922
Aix-en-Provence	358,122
Clermont-Ferrand	282,737
Tours	280,405
Orléans	275,083
Angers	267,119
Perpignan	259,165
Nancy	256,004
Mulhouse	253,504
Dijon	245,685
Lens - Liévin	242,680
Nîmes	239,919
Le Havre	237,066
Metz	217,799
Caen	217,281
Reims	209,421
Brest	206,661
Saint Denis	199,243
Limoges	198,109
Cergy-Pontoise	194,734
Dunkerque	194,642
Valenciennes	190,896
Lorient	186,967
Le Mans	184,466
Versailles	181,024
Besançon	177,517

Avignon	176,729
Amiens	175,024
CA de Sophia-Antipolis	174,277
CC de la Boucle de la Seine	170,904
Fort-de-France	162,081
Douai	151,551

Netherlands	**2013**
Amsterdam (greater city)	1,033,279
Rotterdam (greater city)	978,040
s-Gravenhage	505,856
Utrecht	321,916
Eindhoven	218,433
Tilburg	208,527
Groningen	195,418
Almere	195,213
Breda	178,140
Nijmegen	166,382
Enschede	158,627
Apeldoorn	157,315
Haarlem	153,093

United Kingdom	**2013**
London (greater city)	8,362,500
Greater Manchester	2,708,600
West Midlands urban area	2,446,600
Liverpool (greater city)	1,065,900
Tyneside conurbation	835,000
Leeds	759,600
Greater Nottingham	647,400
Glasgow	595,800
Sheffield	558,700
Bradford	525,500
Portsmouth (greater city)	525,200
Edinburgh	485,100

Leicester (greater city)	483,700
Bristol	435,000
Kirklees	426,900
Cardiff	350,100
North Lanarkshire	337,800
Cheshire West and Chester	330,600
Wakefield	328,700
Coventry	326,500
Wirral	320,300
Reading (greater city)	315,400
Doncaster	303,200
Belfast	281,100
Brighton and Hove	276,900
Sunderland	275,900
Medway	269,700
Southend-on-Sea (greater city)	263,700
Plymouth	258,600
Rotherham	258,500
Kingston-upon-Hull	257,400
Milton Keynes	254,000
Derby	251,000
Stoke-on-trent	250,100
Preston (greater city)	249,400
Southampton	240,800
Swansea	240,000
Barnsley	234,700
Aberdeen	226,100
Northampton	215,700
Swindon	213,000
Luton	206,900
Warrington	204,400
York	201,200
Stockton-on-Tees	192,800
Bournemouth	187,700
Peterborough	187,400

Bath and North East Somerset	178,900
Basildon	177,400
Colchester	176,800
Wycombe	173,600
Basingstoke and Deane	171,200
Chelmsford	169,800
Telford and Wrekin	168,100
Bedford	160,300
Thurrock	160,200
North East Lincolnshire	159,800
Maidstone	158,300
Falkirk	157,000
Oxford	153,700

Appendix 2 - Eligible car sharing platforms

CSO	Website	Alternative website
App2drive	https://www.app2drive.com/	
Auto Bleue	https://www.auto-bleue.org/	
AutoCité	http://autocite.besancon.fr/site-web/index.html	
Autocité+	http://www.sara-angers.fr/deplacement/autocite-plus-angers-autocite+.php	
Autolib	https://www.autolib.eu/en/	
BeiAnrufAuto e.V.	http://www.beianrufauto.de/	
Bluecub	http://fr.cityzencar.com/	
Bluely	https://www.bluely.eu/	
Book-n-Drive	https://book-n-drive.dbcarsharing-buchung.de/kundenbuchung/	
Cambio	http://www.cambio-carsharing.de/?l=en	http://www.cambio.be/
Car2Go	http://www.car2go.com/	
CarUnity	https://www.carunity.com/	
citeecar	https://www.citeecar.com/Home	
Citélib	http://citelib.com/	

Citiz	http://citiz.coop/	
City Car Club	http://www.citycarclub.co.uk/	
City Roul	http://cityroul.com/	
Communauto	https://www.communauto.paris/	
Connectcar	http://www.connectcar.nl/	
Co-wheels	http://www.co-wheels.org.uk/	
DB Flinkster	https://www.flinkster.de/	
Drive carsharing	https://www.drive-carsharing.com/	
DriveNow	https://de.drive-now.com/	https://uk.drive-now.com/
ecar	http://www.e-carclub.org/locations/	
Einfach mobil	http://www.einfach-mobil.de/	
Flexicar	http://www.flexicar.de/	
Ford-carsharing	http://www.ford-carsharing.de/	
Greenwheels	https://www.greenwheels.com/	
Grüne Flotte	http://www.gruene-flotte-carsharing.de/	
Hertz 24/7	https://www.hertz247.de/	https://www.hertz247.com/
KeyLib	http://keylib.fr/	
Lilas Autopartage	http://www.lilas-autopartage.com/	
Marguerite	http://www.imarguerite.com/	
Mobigo Autopartage	http://mobigo.citiz.coop/	
Modulauto	http://www.modulauto.net/	
Move About	http://www.move-about.de/	
Multicity	https://www.multicity-carsharing.de/	
My-e-car	https://www.my-e-car.de/	
MyWheels	https://mywheels.nl/	
Quicar	https://web.quicar.de/	
sGO! Solingen	http://www.sgo-carsharing.de/	
Share a Starcar	https://www.share-a-starcar.de/	
Stadtmobil	http://www.stadtmobil.de/	
Stadtmobil Südbaden	https://www.stadtmobil-suedbaden.de/	
Stadtteilauto Carsharing Münster	http://www.stadtteilauto.com/	

Stadtteilauto Carsharing Osnabrück	http://www.stadtteilauto.info/	
Stadtteilauto München	http://www.stadtteilauto.de/	
Stadtwerke Augsburg Carsharing	https://www.swa-carsharing.de/	
Stattauto Bonn	http://www.stattauto.com/	
Stattauto Kassel	http://stattauto.net/	
Stattauto Kiel & Lübeck	http://www.stattauto-hl.de/	
Stattauto München	http://stattauto-muenchen.de/	
Studentcar	http://www.studentcar.nl/	
teilAuto	http://teilauto.dbcarsharing-buchung.de/kundenbuchung/#	
TOTEM mobi	http://www.totem-mobi.fr/	
Willmobil	http://willmobil.de/	
Zencar	https://www.zencar.eu/nl/	
Zipcar	http://www.zipcar.co.uk/	

Appendix 3 - Correlation matrix

	Shared B2C cars (total)	Presence of B2C carsharing	Log-trans. shared B2C cars	Shared B2C cars per capita	Bikesharing presence	City population (tenthousands)	Population density (pop/km2)	% age 20-24	% age 25-34	% age 35-44	Registered cars per 100 inhabitants	% one person households	% students in higher education	% highly educated population	% communtes by public transport	% commutes by car	Historical city	University presence	% Green party votes	CSO HQ presence	Herfindahl index (B2C)	Carsharing policy
Shared B2C cars (total)	1																					
Presence of B2C carsharing	.146+	1																				
Log-trans. shared B2C cars	.607**	.b	1																			
Shared B2C cars per capita	.536**	.270**	.729**	1																		
Bikesharing presence	.251**	.277**	.522**	.352**	1																	
City population	.789**	.134+	.442**	.185*	.165*	1																
Population density	.541**	.257**	.416**	.289**	.207**	.510**	1															
% age 20-24	-.041	.129+	.139+	.063	.158*	-.021	.104	1														
% age 25-34	.334**	.325**	.546**	.478**	.262**	.270**	.464**	.529**	1													
% age 35-44	.281**	.194**	.208*	.301**	.021	.205**	.372**	-.382**	.289**	1												
Registered cars per 100 inhabitants	-.342**	-.333**	-.387**	-.414**	-.095	-.294**	-.552**	-.208**	-.556**	-.328**	1											
% one person households	.318**	.257**	.676**	.589**	.569**	.081	.247**	.236**	.385**	-.101	-.195**	1										
% students in higher education	-.058	.169*	.129	.164+	.076	-.082	-.075	.448**	.431**	-.079	-.069	.165*	1									
% highly educated population	.332**	.177*	.567**	.438**	.290**	.248**	.260**	.458**	.553**	.135+	-.144+	.415**	.378**	1								
% communtes by public transport	.686**	.198**	.725**	.512**	.379**	.582**	.581**	.015	.431**	.291**	-.352**	.419**	.051	.433**	1							
% commutes by car	-.533**	-.305**	-.736**	-.596**	-.524**	-.368**	-.561**	-.333**	-.606**	-.273**	.510**	-.638**	-.122	-.661**	-.697**	1						
Historical city	.199**	.099	.401**	.220**	.259**	.215**	.107	.373**	.277**	-.281**	-.082	.361**	.161+	.440**	.280**	-.328**	1					
University presence	.299**	.392**	.640**	.429**	.452**	.293**	.335**	.441**	.556**	.022	-.451**	.462**	.320**	.489**	.431**	-.528**	.416**	1				
% Green party votes	.246**	.209**	.635**	.583**	.403**	.050	.175*	.213**	.392**	.051	-.139+	.599**	.257**	.328**	.441**	-.437**	.257**	.389**	1			
CSO HQ presence	.360**	.158*	.487**	.366**	.166*	.306**	.295**	-.045	.316**	.230**	-.242**	.332**	.028	.263**	.436**	-.406**	.164*	.218**	.320**	1		
Herfindahl index	-.261**	.b	-.467**	-.363**	-.162+	-.168*	-.178*	.127	-.175*	-.201*	.191*	-.303**	-.021	-.108	-.288**	.221**	-.034	-.210*	-.410**	-.335**	1	
Carsharing policy	.411**	.214+	.613**	.520**	.370**	.247+	.458**	.183	.655**	.257*	-.353**	.550**	.135	.486**	.435**	-.527**	.300*	.442**	.488**	.393**	-.209	1

**. Correlation is significant at the 0.01 level (2-tailed). | *. Correlation is significant at the 0.05 level (2-tailed). | +. Correlation is significant at the 0.10 level (2-tailed).

b. Cannot be computed because at least one of the variables is constant.