# A CITY-LEVEL ANALYSIS OF ONE-WAY VEHICLE SHARING IN THE NETHERLANDS

Master's thesis – Master Sustainable Business and Innovation


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# ABSTRACT

Vehicle sharing has the potential to reduce social and environmental impacts of traffic. Vehicle sharing services are offered by digital platforms, who operate in cities with different characteristics and these services employ different business models. The understanding of the location decisions of vehicle sharing platforms remains limited. While prior studies on vehicle sharing address consumer adoption, vehicle supply and conceptual frameworks of vehicle sharing’s markets and business models, this research extents existing knowledge on the one-way vehicle sharing business model specifically by proposing a theory of local imitation. Imitation is caused by the presence of a vehicle sharing business models within a location, attracting vehicle sharing platforms that offer other mobility types to that location. Imitation of practices was addressed by scholars as the idea that firms adopt new practices more presumably after observing others adopting these practices first. This thesis extends existing knowledge by focusing on the geography of these practices and empirically tests the occurrence of imitation on a local level. The findings suggest that location choice of vehicle sharing platforms could be driven by such an imitation process. Moreover, the results confirm that vehicle sharing platforms are dependent on demographic city characteristics as the literature suggests, and advances that such demographics are important for one-way vehicle sharing platforms specifically.

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# 1. INTRODUCTION

## 1.1 BACKGROUND

The need for sustainable mobility in cities is increasing as urbanization is ever growing (Banister, 2008). Transport systems in their current form are associated with negative impacts on urban livability and the environment (Firnkorn & Müller, 2015; Friedrich & Bickel, 2001; EEA, 2006; Infras, 2004). Therefore, a transition towards a sustainable mobility system is desired. To achieve such a sustainable mobility system, three innovations can be proposed: the replacement of fossil powered vehicles with electrical substitutes, the introduction of autonomous vehicles and the shift from private ownership to shared vehicles (Sperling, 2018). Whereas the first two innovations are likely to be largely dependent on future technological developments, shared mobility can be implemented with existing technology. Because of this, scholars point to modes of transport that provide access over ownership as a solution (Münzel, 2020; Bardhi & Eckhardt, 2012).

At present, the ownership of private vehicles, that of cars in particular, is embedded in our social and cultural systems (Münzel et al, 2020; Meelen et al, 2019; Nykvist and Whitmarsh, 2008; Hoogma et al., 2005). Private ownership has the tendency to result in the underutilization of cars and other vehicles because the use is mostly restricted to the owner. However, with the rise of the digital platform economy, multiple alternatives that are not based on ownership have been introduced in the past decennia, offering various shared vehicles in several ways (Shaheen & Chan, 2016). The digital platform economy is a somewhat poorly understood concept that evolves from the notion of ‘collaborative consumption’ (physical commodities and services) and is associated with the online digital organization of economic and social activity (Kilhoffer et al., 2017; Kenney & Zysman, 2016). Other general labels used to describe this topic are “sharing economy” (Frenken & Schor, 2019), “collaborative economy” (Botsman & Rogers, 2010) and “gig-economy” (Friedman, 2014). The present study views the ‘digital platform economy’ as the overarching term to describe the economic system that may deemphasize ownership of goods through collaborative consumption, making use of digital platforms.

When new platform business models are introduced to existing sectors, a disrupting impact is often inevitable, heavily affecting the established organization of economic activity by resetting entry barriers, challenging regulation and reshaping consumer behavior (Kenney & Zysman, 2016). As the traditional business models of many corporations are based on the ownership of goods, disruptive innovations of the platform economy could radically transform markets (Kenney & Zysman, 2016). Perhaps the most noted sector that is disrupted by platforms is the mobility sector (Geissinger et al., 2020). Shared mobility is amongst the fastest growing markets within the platform economy and is expected to continue to grow (Shaheen & Cohen, 2019; Cohen & Shaheen, 2016; Shared-use mobility center, 2015). Shared mobility is an umbrella term describing a sector of the platform economy that offers mobility in different ways, ranging from services where the vehicle itself is shared (vehicle sharing) to services where the ride is shared (ridesharing) (Shaheen & Chan, 2016; Cohen & Shaheen, 2016). Vehicle sharing may reduce vehicle ownership and cause positive environmental, social and transportation-related impacts as indicative evidence suggests (Shaheen, 2016).

In an emerging market like vehicle sharing, many different business models co-exist. The search for a dominant model, that could become the standard is currently going on in vehicle sharing markets (Morris et al., 2005), which could lead to one prevailing business model most firms will employ (Teece, 2010). Four main vehicle sharing models that compete in vehicle sharing were identified based on literature (Shaheen & Chan, 2016; Münzel, 2020) as displayed in Figure 1: peer-to-peer, round-trip, one-way and cooperatives.

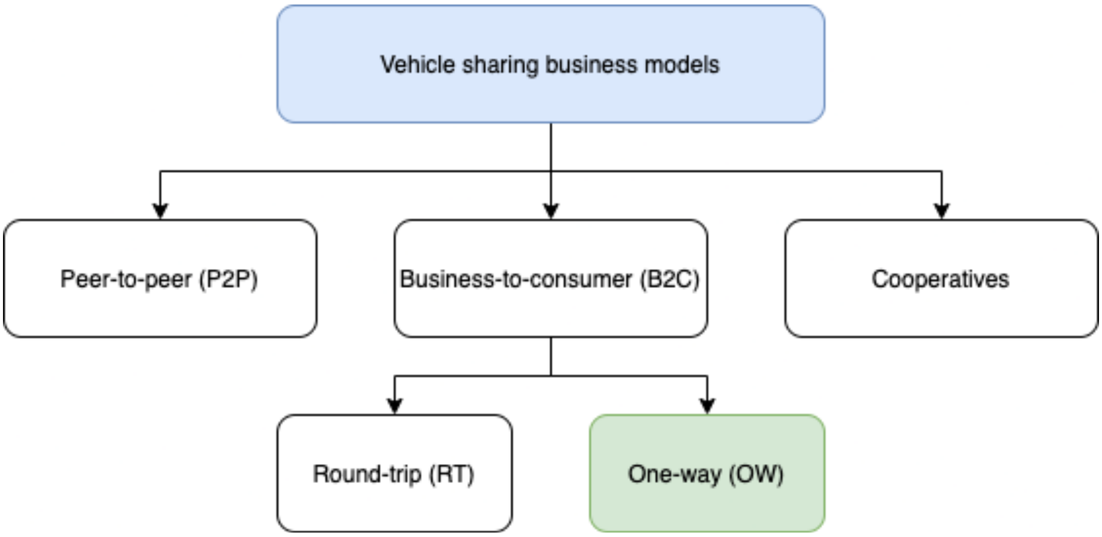



FIGURE 1. VEHICLE SHARING BUSINESS MODELS

In recent years, increasingly more business-to-consumer (B2C) sharing vehicles are being offered, both in the Netherlands and worldwide (CROW, 2018; Shaheen & Chan, 2016; Gu et al., 2019).

The one-way business model (OWBM) has seen a rapid increase in use, especially for carsharing (Shaheen et al., 2015a), but also bike- and scooter sharing systems make use of a similar one-way model (van Waes et al., 2018; Caggiani et al., 2018; Ji et al., 2014; Howe & Bock, 2018). Different from round-trip travel, one-way sharing allows the consumer to flexibly rent a vehicle at one place and drop it somewhere else (Shaheen & Chan, 2016). Typically, one-way models can be divided into two types: free-floating and station based (Shaheen et al., 2015b; van Waes et al., 2018; Caggiani et al., 2018; Correia et al., 2014). While another model is sometimes conceptualized, "geofencing" mostly for bike sharing systems (Janmaat, 2019), this model is usually not considered by scholars and therefore neglected in this study. With free-floating, the consumer can drop off the vehicle anywhere in the designated city area (Shaheen et al., 2015b). This model can be considered most flexible as it often provides travel to the exact location that is desired. The vehicle can be parked according to local regulations (e.g. City of Berkley, 2020). The station-based model offers consumers to return the vehicle at the same or a different physical station of the provider that is available (Shaheen et al., 2015b). For bikes this may be a bicycle stand owned by the provider and for cars it could be designated parking spots. The flexibility of this model is dependent on the fleet size and number of stations. One-way models are one of the newest models amongst the vehicle sharing business models (Münzel, 2020; Shaheen et al., 2015a) and have potential to provide social and environmental benefits (Shaheen et al., 2015a). The free-floating model in particular has a growth potential

(Kortum et al., 2016). Also, one should keep in mind the developments in autonomous vehicles, that would most likely operate under some sort of one-way model (Winter et al., 2016).

## 1.2 RESEARCH GAP AND RELEVANCE

Previous work on vehicle sharing addresses the need for urban characteristics to be present in a location for its business models to flourish (Münzel, 2020; Civitas, 2016). Local urban factors such as population size and density, level of education, age and household composition have been associated with the presence of vehicle sharing business models (Münzel 2020; Hu et al., 2018; Juschten et al., 2019; Coll et al., 2014; Du et al., 2019; Martin & Shaheen, 2014). The most influential local factors to attract vehicle sharing could be population size and population density, especially for carsharing (Münzel, 2020;), but also for bike sharing (Du et al., 2019). We expect (one-way) platform companies to consider such city characteristics in their location choices. Münzel (2020) demonstrated that one-way carsharing business models exist mainly in the largest cities, possibly due to its density benefits. This research further examines the dependence of the OWBM on 'urbanity'. It remains unclear to what extent one-way vehicle sharing depends on urban characteristics of a city, specifically for other types of mobility then carsharing. This issue motivates the first academic gap, which is addressed through the following research question:

*RQ1: To what extent is the location choice of one-way vehicle sharing business models influenced by the urbanity of a city and how does this differ per type of mobility?*

While one-way models exist in different mobility markets, the business models remain virtually unchanged. Another research gap addresses how these models could attract each other within a city or town. As previously discussed, the location choice of vehicle sharing services can be influenced urban conditions that are locally present. However, it remains unspecified if the local presence of a business model in one mobility market could attract a similar business model from another mobility market within a geographical location. Münzel (2020) briefly mentions how carsharing systems may benefit from bike sharing in the same location and the other way around. She outlines how consumer familiarity with the business model and consumer dependence on shared mobility could favor both mobility types. This is known as a spillover effect amongst innovations (Jaffe et al., 2000). Such local spillovers could lower the entry barriers for firms that operate in other mobility markets and in term encourage more firms to enter the market in that location. Business models that are identical, or at least very similar, could benefit more from these spillover effects and lowered barriers compared to business models that are not. Adopters of the one-way car sharing models would for instance adopt the one-way bike sharing model more easily because they are familiar with the way it works (Münzel, 2020). Besides consumer adoption, other local conditions are influenced by the market entrance of one-way business models, such as local regulations and knowledge. The present paper further conceptualizes these potential spillover effects amongst innovations in the context of the one-way vehicle sharing platforms that offer vehicles in different markets (car, scooter and bike). Such spillover effects could provoke imitation of business models, a strategy that plays a dominant role in the diffusion of innovations and practices in general (Shipilov et al., 2010; Jovanovic & MacDonald, 1994; DiMaggio & Powell, 1983). As spillover effects play on a local level, the imitation process could play on the local level as well. In the context of this study, local imitation is seen as the process where an existing business model in one market (e.g. bike sharing market) is adopted in another market (e.g. carsharing market) within a geographical location that is confined by admirative borders, such as a city or town. To gain insight in the local imitation process of one-way vehicle sharing, the study aims to measure the influence of the local presence of OWBMs on the location choice of new entrants who introduce the same OWBM within a geographic location by answering the following research question:

*RQ2: To what extent is the location choice of a one-way vehicle sharing platform (e.g. car) influenced by the presence of the one-way vehicle sharing business model in related mobility markets (e.g. bike or scooter), within a geographic location?*

# 2. Theory

## 2.1 Disruptive platform innovations and local institutions

Innovation can be understood as a recombination of existing knowledge (Schumpeter, 1939), a new or substantially improved product, service or process that adds value for commercialization (Rogers, 1993). It is important to note that 'new' or 'improved' can imply new to a firm or organization, not necessarily to every observer. Innovations spread through diffusion, a process that is observed in virtually everything: rumors, preventive prescriptions, boiling water, viruses, software and information (Rogers, 1995; Strang & Meyer, 1993). Diffusion in the context of innovation is the process by which an innovation is communicated over time through channels in a social system (Rogers, 1995). Getting a new idea adopted however, does not happen by itself. Many innovations require time and effort to be adopted by the public and some never succeed. As organizations and individuals are eager to speed up the rate of diffusion of an innovation, resistance is experienced. Resistance could arise when an incumbent firm is challenged by the introduction of an innovation and brings forward the disruptive nature of some innovations (Christensen et al, 2015). Disruptive innovations typically seek a new customer base, often price-sensitive non-consumers who cannot afford or do not deem the full-featured product or service necessary (Christensen et al, 2015; Osiyevskyy & Dewald, 2015). Over time, the disruptive innovation may gain momentum, develop, thereafter surpass the incumbent technology by fetching over their consumers (Osiyevskyy & Dewald, 2015).

From an institutional point of view, disruptive innovations are new organizational activities that push to change the institutional structure, such as norms of market organization, regulatory frameworks and consumer behavior (DiMaggio & Powell, 1983; Scott, 1995). Institutions have been defined in several ways. It can be seen as the set of elements that underline cognitive, normative and regulative structures that provide stability and meaning to social environments (Scott, 1995). This leads to the notion of legitimacy, something that disruptive innovations seek to ensure continuity for their new activities (Geels & Verhees, 2011). Something is legitimate if it is conforming with the rules, beliefs, values and procedures of a group, for example regulatory bodies, organizations and social communities (Zelditch, 2001). When disruptive innovations challenge institutions, it can create, maintain or disrupt existing institutions (Lawrence & Suddaby, 2006; Mair & Reischauer, 2017; Ben-Slimane et al., 2020). Institutions are created when practices establish and legitimize a new institution. Maintaining refers to unchanged institutions, despite the efforts to change them. The disruption of institutions occurs when practices aim and succeed to change existing institutions.

An approach that considers the role of institutions is particularly useful to study entry decisions of platform companies. Platforms are often seen as disruptive innovations and tend to challenge local institutions (Geissinger et al, 2020; Mair & Reischauer, 2017; Laurell & Sandström, 2016). For instance, when platforms defy local regulations by entering the market first and only asking for permission later (Thelen, 2018; Pelzer et al., 2019). Platforms that challenge local institutions by introducing their business models to a market can shape institutions due to their disruptive nature while aiming for legitimacy. Attaining legitimacy may be challenging however, since these platforms often disrupt existing institutions and therefore face resistance from regulatory bodies, organizations in the traditional economy and social groups.

Platform innovations are known to quickly spread across regions (Stallkamp & Schotter, 2019; Mair & Reischauer, 2017). The innovations of the past decades in information technology have enabled many, but not all, sharing platforms to escape location boundness (Stallkamp & Schotter, 2019). These sharing platforms and their business models can diffuse virtually freely as they face few transaction costs, capacity constraints and often no large capital investments (Stallkamp & Schotter, 2019). Internet connectivity has enlarged the geographical scope of some platforms, allowing transactions between consumers over great distances. However, not all platforms are location-independent and are thus more tied to their geographical location. Stallkamp & Schotter (2019) mention this is the case for transportation platforms. For such location-bound platforms, entering a new geographical market requires certain capabilities such as capital investments, localized knowledge and the building of local networks (Mair & Reischauer, 2017; Elg et al, 2008). One-way vehicle sharing is an example of such location bound platforms as its B2C platforms own assets such as cars, bicycles or scooters that require capital investment and are often tied to urban areas. The study specifically focusses on these location-bound platforms that disrupt and reshape local institutions. In their location decisions, we expect platforms to consider the local institutional context. Due to their location boundness, location-bound platforms cannot escape friction with local institutions.

## 2.2 BUSINESS MODEL IMITATION

Scholars initially put emphasis on discontinuous technological innovation when studying disruption (Christensen & Bower, 1996; Christensen, 2013). However, the business models that carry these technologies can also be seen as disruptive innovations (Christensen & Raynor, 2013). Christensen (2006) argues it is the business model that creates the disruptive impact, the technology is merely the predecessor. Therefore, the success of an innovation depends on the business model that serves as a vessel to diffuse it (Long et al, 2016; Boons & Ludeke-freund, 2013; Chesbrough et al, 2006). Likewise, Chesbrough et al (2006) stress the importance of the business model: *"a mediocre technology pursued within a great business model may be more valuable that a great technology exploited via a mediocre business model'' – p. 354.* There is no established definition of what a business model exactly is, but it can be seen as the conceptual model of a business that aims to capture, create and deliver value to its customers (Chesbrough, 2007; Chesbrough, 2010; Teece, 2010). In a business model, implicit assumptions are made about costumers in order to capture value, estimate their behavior and needs and competitor responses. It conceptualized the business logics needed to make profit and defines the way a firm 'goes to market' (Teece, 2010). Both incumbent firms and new entrants are known to strategically mimic the original disruptive approach (Osiyevskyy & Dewald, 2015;

Casadesus-Masanell & Zhu, 2013; Pisano, 2006) in their business models, demonstrating that (disruptive) business models are prone to imitation (Teece, 2010). In essence, this is illustrated by the idea that firms seem to adopt new practices more presumably after observing others adopting these practices first (Shipilov et al, 2010; DiMaggio & Powell, 1983). Thus, innovators usually design business models in reference to existing business models before entering a market (Ritter & Schanz, 2019). Therefore, most successful business models will eventually, at least to some extent, be imitated by other firms (Teece, 2018). The 'razor-blade model' and the 'newspaper revenue model' are examples that have been replicated with little variance in thousands of geographically separate markets (Teece, 2010). This process of imitation is known to be one of the main forces behind the diffusion of practices (Shipilov et al, 2010), such as the introduction of business models in new locations. By the time products or services are introduced outside of the original location, the potential of entering a geographical market might be easy to recognize, but uncertainty remains about economic drivers such as market size and growth potential in that location (Helfat & Lieberman, 2002). Some studies look beyond economic drivers that may affect location choice, such as institutional factors (Dunning & Lundan, 2008; Flores & Aguilera, 2007; Yang, 2018).

Three types of institutional factors are suggested to be shaped by location-bound platform companies. First, local knowledge can be strongly bounded in space and could spillover, which allows companies nearby to introduce innovations easier and faster than competing firms operating elsewhere (Breschi & Lissoni, 2001). Local knowledge spillovers can be seen as an externality bounded in space that stems from the development of an innovation which can end up facilitating other innovation efforts (Breschi & Lissoni, 2001). This can be unintentionally, as other actors imitate the innovation or intentionally when knowledge is shared willingly. Therefore, location-bound business models might prefer market entry in a geographic location where similar business models exist because they can profit from local knowledge spillovers. Localized knowledge can include firms' strategies that are specific for a particular city, such as how they introduce their business model, address consumers and communicate with local governments. As others observe these processes, this knowledge may transmit (or spillover) to them.

Second, market entrance of platforms provokes regulatory responses from regulatory bodies (Thelen, 2018). It is usually city governments that (must) adapt their regulatory frameworks to accommodate or oppose platforms (Thelen, 2018; Woolf, 2016). As the market entrance of platforms is often disruptive, this can create new or change existing institutions such as regulation, law and spatial planning policies. These regulations are not always necessarily shaped in favor of the entering platform however, as prohibiting regulation could be implemented (Thelen, 2018). However, when the platform *is* welcomed by the local municipality, and the regulations are shaped in its favor, these conditions may be considered by competing platforms in their location choice, having them choose that particular municipality over another.

Finally, legitimacy of vehicle sharing business models can affect consumer behavior. Consumer behavior in this sense is changed by acceptance and adoption of platform models in general or vehicle sharing platforms specifically. Such consumer acceptance could be crucial for the success of vehicle sharing business models (Münzel, 2020; Abdelkafi et al, 2013). When a vehicle sharing business model gains legitimacy in a location amongst consumers, it is likely that those consumers will adopt the business model for other mobility form more easily. For example, as when a group of consumers in a city get familiar with the one-way carsharing model and they are satisfied with its procedure, it may lead to a habit of using the model. This habit can transmit to the use of other one-way sharing models, such as the bike or scooter sharing model.

The three institutional factors can thus be shaped by the introduction of a platform, gain legitimacy for its business model and spill over. This study argues these spillover effect of innovations (Jeffe et al., 2001) lower the entry barriers for vehicle sharing firms and enable other vehicle sharing platforms to introduce their business models more easily nearby than far away. When competitors in related markets benefit from such lowered entry barriers by mimicking the existing business model within a geographic location, the study treats this process as 'local imitation'. Local imitation is thus concerned with the 'initial introduction' within markets, rather than following introductions in those markets. An initial introduction occurs when a local mobility market experiences an introduction of the OWBM for the first time, whereas following introductions occur when a local mobility market (car-, scooter- or bike sharing market) experiences an introduction of the OWBM for the second, third or n[th] time.

## 2.3 IMITATION HYPOTHESES

As discussed in the theory, the introduction of location-bound business models such as vehicle sharing business models shape local institutions creating legitimacy for the business model locally. While market entry of a platform in one market (e.g. car) creates legitimacy for its business model in its own market, it could also create legitimacy for the business model in related markets (e.g. bike or scooter). The legitimacy created by an introduction in market A can thus attract actors in related markets B and or C as visualized in Figure 2.

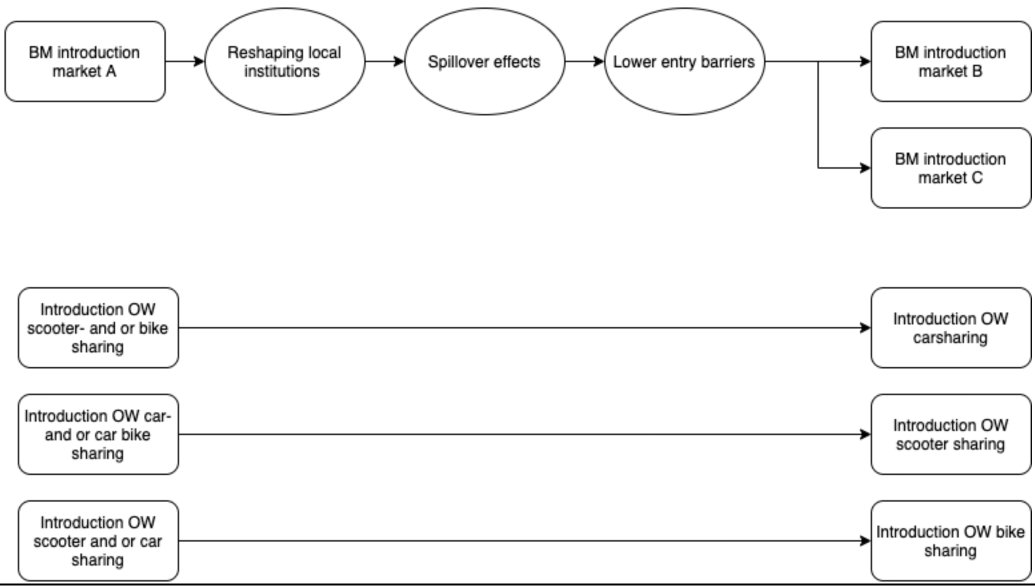



FIGURE 2. CONCEPTUALIZATION OF THE DIFFUSION PROCESS OF LOCATION BOUND AND VEHICLE SHARING BUSINESS MODELS

These theoretical assumptions of location-bound business models are measured using the case of one-way vehicle sharing models within the three mobility markets: car-, scooter- and bike sharing. It is expected that a one-way bike sharing platform prefers to introduce its business model in a location where a similar scooter or carsharing business model is already present.

This is schematically illustrated by the lower part of Figure 2. To empirically test to what extent the local presence of location-bound business models in one market affects the likelihood of an introduction in a related market on a city-level, three hypotheses are proposed:

> *Hypothesis 1 the local presence of one-way scooter and bike sharing business models increases the likelihood for a one-way carsharing business model to be introduced in that location.*
>
> *Hypothesis 2 the local presence of one-way car and bike sharing business models increases the likelihood for a one-way scooter sharing business model to be introduced in that location.*
>
> *Hypothesis 3: the local presence of one-way scooter and car sharing business models increases the likelihood for a one-way bike sharing business model to be introduced in that location.*

Note that the hypotheses aim to measure local imitation of two other markets. A hypothesis can thus be partially true, for example when bike sharing presence attracts carsharing, but scooter sharing does not attract carsharing.

Using these hypotheses, the study aims to contribute to the understanding of diffusion processes of location-bound business models in general and one-way vehicle sharing business models specifically. Most theories on diffusion with respect to the platform economy disregard geographical and administrative boundaries (e.g. Schaltegger et al, 2016; Ciulli & Kolk, 2019; Mair & Reischauer, 2017). By studying to what extent one-way vehicle sharing business models attract each other in Dutch municipalities, an academic contribution can be made about the diffusion and imitation process on a city-level.

## 2.4 DEMOGRAPHIC CITY CHARACTERISTICS

Shaheen et al (2021) have studied why consumers choose certain shared mobility modes over others. Their study identifies various urban forms which explain consumers' travel behavior. More scholars have emphasized that vehicle sharing platforms generally rely on urban factors (Juschten et al., 2019: Coll et al., 2014; Du et al., 2019; Martin & Shaheen, 2014). Demographic city characteristics such as population density, household size and age are key factors that could explain consumer demand for vehicle sharing (Faghih-Imani et al., 2014; Kortum et al., 2016; Deloitte, 2014).

As vehicle sharing platforms rely on consumer usage, we expect them to seek locations to operate where they can meet consumer demand. Therefore, demographic city characteristics are expected to be considered by vehicle sharing platforms in their location decisions. It is however poorly understood to what extent different business models of vehicle sharing and its different mobility types depend on these urban characteristics. Münzel (2020) found that one-way carsharing exists in the largest cities in Germany. However, no empirical evidence has demonstrated the extent to which one-way vehicle sharing depends on demographic city characteristics, especially not for car- scooter and bike sharing within the same study. To gain further insight in the dependence of one-way vehicle sharing on demographic city characteristics, the following hypotheses are proposed:

*H4: One-way vehicle sharing is dependent on demographic city characteristics.*

*H5: The degree to which one-way vehicle sharing is dependent on demographic city characteristics differs among one-way car- scooter- and bike sharing.*

# 3. METHODOLOGY

## 3.1 RESEARCH DESIGN

To answer the research questions and hypotheses, a quantitative research approach was chosen because: (1) the hypotheses that were deduced from theoretical considerations must be subject to empirical scrutiny, (2) it requires numerical data collection and analyzation to translate the concepts into researchable entities and objectively test the theory and (3) quantitative analysis allows to estimate the degree of the relationship between concepts more precisely than qualitative measures.

A combination of cross-sectional and longitudinal research design was used. With such a dual design, the aim was to gain insight in: (1) the time order of variables which allows causal inferences to be made and (2) variation across municipalities by considering many cases. By selecting many cases and seeking variation, generalization is possible, allowing an understanding of the wider theory instead of case specific knowledge. Furthermore, this study aims to further the understanding of a process of local imitation, where business models ‘follow’ each other to a location. Because such processes occur continuously over time, a longitudinal design was chosen.

## 3.2 SAMPLING

The ideal sample to test the hypothesis consists of many municipalities that are candidates for one-way vehicle sharing. The criteria for a municipality to be a candidate for shared mobility remain unspecified, as literature on the subject still needs to mature. However, a high population density and a large city size are often referred to as crucial factors (e.g. for carsharing: Hampshire and Gaites, 2011; Millard-Ball et al., 2005) as well as connectivity to internet (Finck & Ranchordás, 2016; Shaheen et al, 2015; Münzel, 2020). Many Dutch municipalities meet these criteria and therefore the Netherlands was selected to study. The Netherlands experienced substantial developments in shared mobility (Meelen et al., 2019; van Waes et al, 2018) and the first vehicle sharing service has been registered since 2011 (Kortum et al, 2016). There are many cities with a high population density (CBS, 2020) and the Netherlands is the leading country in Europe regarding internet access (CBS, 2018). Additionally, studying the Netherlands does not form language constraints for data collection as my native language is Dutch.

The cases (municipalities) were sampled based on population size and density as these are crucial criteria for vehicle sharing. Vehicle sharing is often viewed as an ‘urban’ phenomenon (e.g. Shaheen & Cohen, 2007). Therefore, the municipalities were included in the sample when categorizing as urban according to the European Union (Dijkstra et al, 2014) who define urban areas as: 300 inhabitants per square kilometer with a minimum of 5000 inhabitants. The

Netherlands has 232 municipalities that meet these criteria (CBS, 2021a). The sample thus consist of a population of all municipalities within the Netherlands that meet these two criteria.

The study period of 123 months between January 2011 up until March 2021 was determined. Since in 2011 the first one-way service emerged in the Netherlands, this year initiates the study period. March 2021 was the final month included in the study period to include as many introductions as possible.

## 3.3 DATA COLLECTION

Desktop research was conducted to create the dataset of municipalities and introduction dates. The data collection process consists of two phases: first, the firm names and the municipalities in which they operate were identified, and second the month of entry for all these municipalities was determined. Appendix A.1 presents all firm names and the number of Dutch municipalities in which they operate. Appendix A2 to A.4 presents all municipalities in which these firms operate and provides the month of entry. For the first phase of data collection, the primary source of data was news articles. Additionally, the websites of sharing platforms, their mobile applications, forums that are concerned with shared mobility were used to assist the data collection in the first phase. Because few vehicle sharing firms provide comprehensive information on the location and time of their local market entries, in the second phase of data collection news articles of local newspapers proved the best source to track down the timing of all business model introductions in Dutch municipalities. Imaginably, local newspapers usually write an article when a sharing service emerges in their municipality. Sometimes an exact date was given and sometimes the articles specified a day in the past week. Consequently, providing an exact date of local market entry was not always feasible but quite accurate estimations could be made for the month of introduction. While for some business models the entry date was not provided by news articles, the internet archive[1] was used to assist the search for the month of entry. To construct the dataset, the 232 municipalities were carefully reviewed in two phases. The reason for the first and second phase to be separated was that determining the month of introduction in the second phase was much more labor intensive. The first phase was initiated to determine in which municipalities one-way vehicle sharing were present, resulting in less municipalities to be researched in the more labor intensive second phase. While the process was iterative, these two phases provided directive guidelines to execute the data collection.

Phase 1 focused on the municipality in which the business model introductions occurred by company name. While the aim was to collect only the first introduction of a mobility type within a municipality, few sources provided such an insight. Therefore, all introductions within all municipalities were traced, in order to determine which were the first. This conveniently provides additional statistics about all business model introductions for the results.

[1] www. https://archive.org/ is an online archive that saves historical web data. The archived pages are saved since 1996.

To my knowledge, no database exists for the location of vehicle sharing services. While some databases provide some inside (e.g. Bikesharingworldmap[2]; Alride[3] and Gaiyo[4]), none of these encompasses all business models introduced, especially not filtered on business model and mobility type, making it harder to only collect data on OWBMs. To ensure that most locations of one-way sharing services in the Netherlands were retrieved, the municipalities were researched one-by-one making use of the search engine “Google” using targeted search terms to narrow down the search. Two types of filters were used: targeted search terms and the Google “news” filter. The news filter provides only news articles, omitting often irrelevant websites. For bike- and carsharing, all municipalities within the sample were scanned individually, using targeted search terms such as: “Amsterdam” AND “carsharing”. To be rigorous, a few variations on these terms were used such as spacing between the word “car” and “sharing” as well as Dutch translations of the terms. For large cities both Dutch and English was used because of their more international nature, while primarily Dutch was used for municipalities under 100.000 inhabitants. Each time an article was found stating that a vehicle sharing service was introduced to the municipality, the business model of the service was reviewed to determine whether it qualified as one-way, according to the definition of one-way vehicle sharing business models as provided in the introduction of this paper. First, the news article was read to determine its business model type. When the news articles provided unclear information about the way the business model works, the service’s website was studied to determine if the business model type was one-way. All services that employ a different business model were listed to avoid encounter with these in municipalities that were studied afterwards. This resulted in a raw dataset providing all locations of car- and bike one-way business models in the Netherlands.

For scooter sharing a slightly different approach was used. It was noted that only three scooter providers exist in the Dutch market (Blok, 2021), which all use a one-way business model. The mobile applications of these providers were used to find all location of one-way scooter sharing business models in the Netherlands (Check, Felyx and GoSharing). Mobile applications provided all locations in which the scooter services are active, in contrast to the services’ website which sometimes did not report small or recently added municipalities. These mobile applications have maps of their survice area’s instead of a list of municipality names in which they are active. To find all locations of one-way scooter models, the maps of the three mobile applications were held next to a map of all Dutch municipalities and its geographical borders (Gemeenteatlas.nl). By carefully comparing the locations of service areas with the municipality map, the locations of all one-way scooter sharing model could be determined in the Netherlands.

The now created dataset included all locations (by municipality) of one-way business models in the Netherlands listed by company name. These lists are equivalent to the first two columns of the tables in appendix A.2, A.3 and A.4 for all three mobility types. This basis provided the starting point for phase 2, where month of market entry was to be determined for all previous identified local business models. All municipalities from this list (thus excluding municipalities

[2] www.bikesharingworldmap.org is a map showing the location of bike sharing systems worldwide.
[3] Alride is a mobile application sharing that tries to make scooter sharing easier by integrating all services in one application.
[4] Gaiyo is a mobile application that tries to make shared mobility easier by integrating all forms of vehicle sharing in one application.

without OWBMs) were reviewed one-by-one again, this time looking for the entry date of the companies in the list. It should be noted that one municipality may contain more than one OWBM. A similar search strategy as for phase 1 was applied to these company-municipality combinations, since news articles provided the main source for the data again. The Google search engine was used to retrieve news articles containing the month of entry of the services that were determined during phase 1. For instance, for the introduction month of the carsharing service CAR2GO in Amsterdam: “CAR2GO” AND “Amsterdam” AND “launch”. Other terms included, but were not limited to: “start”, “since” and “from now on”. Again, the Dutch translations of these terms were used for municipalities under 100,000 inhabitants, while both Dutch and English were used for the larger cities with a population over 100,000. Various combinations of such terms were used for rigorous sourcing of the desired data. This process was executed for all mobility types and therefore added column 3 to 5 to the tables as shown in appendices A2 to A4. The entry date was retrieved from the articles and is shown in column 3. The article was referred to through a hyperlink in column 4. Column 5 presents the date of retrieval of the source.

Near the end of phase 2, the datasets as shown in the appendices A2 to A4 were completed except for a few missing entry dates. These missing dates were determined by using two alternative methods. First, vehicle sharing firms were directly contacted by email, requesting data on time of market entry. This process was initiated during phase 1 and continued throughout the data collection process. While few responded, some provided useful data (Felyx and Uwdeelfiets). Second, the Internet Archive Waybackmachine (internet Archive, n.d.) was used to assist the data collection. The website offers over 500 billion screenshots of webpages from years back. This allows to go back in time and collect data from the mobility providers’ websites. Thereby, estimations were be made for the date of market entrance for the remaining locations. For example, if in March the sharing company’s website advertises ‘’coming soon in The Hague” and in April the website states the service is offered, it was deemed reasonable to assume the company launched their business model in the Hague in April.

## 3.4 Operationalization

Three analyses were carried out: one for car-, scooter- and bike-sharing separately. The raw datasets in appendices A2 to A4 were transposed to longitudinal datasets, consisting of a month-municipality combination. All municipalities in the dataset were included 123 times, one time for every month within the study period. This formed the basis for the dependent variable which was binary coded for the event: 1 for the event of an introduction of a business model in month *t* in municipality *i* and zero otherwise. The resulting dataset was transformed to a survival format for the Cox regression.

To test to what extent the demographic city characteristics increase the attractiveness of local one-way sharing markets, four variables were used: population size, population density, household composition and demographic pressure. The existing literature as discussed in the introduction and theory addresses population size and density as the most important attracting urban factors for vehicle sharing, specifically for carsharing. Furthermore, household composition can be associated with vehicle sharing as it was found that smaller household are more eager to use vehicle sharing, specifically carsharing (Meelen et al., 2019; Müller et al, 2017). Finally, demographic pressure can be associated with vehicle sharing because of two reasons. First, as the required age for driving cars and scooters is 18 and 16 respectively in the Netherlands, young people cannot use can and scooter sharing. Second, the early adoption of emerging innovations is known to be by young age groups (Rogers, 2003). Therefore, demographic pressure is expected to have a negative effect on the location choice of one-way vehicle sharing services. The data was retrieved from CBS statline and the specific references are displayed in table 1. While the data was not available for the year 2020 and 2021 and both variables did not vary much over time, the 2019 data was used for all observations.

To measure to what extent local imitation of OWBMs occurs, only the first OWBM introduction within a municipality for each mobility type was considered in the dependent variable. When a second, third or $N^{th}$ one-way carsharing business model is introduced, this was not considered in the regression analysis. This is because the imitation analysis aims to measure the attractiveness of a local market based on business model presence in the related markets rather than attractiveness of the local market based on the presence of the same mobility type. Also, larger cities could host more different services of the same mobility type because of their size. This is not something we want to influence the imitation decisions. The main dependent variable consists of Dutch municipalities with the introduction of OWBMs at a particular moment in time and measures the event of the first OWBM introduction. The longitudinal datasets were used to create this time-varying dummy variable for all three mobility types. This allows to measure the time between OWBM introductions in the various municipalities within the dataset.

To measure the relation between the dependent variable and the presence of OWBMs of the other mobility types, two time-varying dummy variables were constructed for each imitation analysis. For the carsharing analysis for instance, one variable to measure the presence of one-way scooter sharing in a focal municipality and one variable to measure the presence of one-way bike sharing in a focal municipality. The explanatory variables in this example thus measure whether the initial introduction of other mobility types occurred before the introduction of one-way carsharing in a specific municipality and at a specific time.

To control for the local attractiveness one-way car sharing, car ownership was used as a variable. For the scooter- and bike sharing analyses, a variable cyclist-friendliness was constructed. Furthermore, income, public transport and surface area were included in all analyses since these factors can be associated with vehicle sharing. A high income could allow people to pay for vehicle sharing on the one hand, while on the other hand lower incomes could discourage people to buy vehicles and therefore use vehicle sharing. Surface area could possibly stimulate the use of one-way vehicle sharing because of the larger distances within a municipality that have to be travelled. Public transport could either have a positive or negative influence on vehicle sharing, depending on complementary or substitutive use of public transport. Car ownership is included as a proxy for the average number of cars owned per household in each municipality and is retrieved from CBS statline (CBS, 2021a). While not all years were represented in the CBS data and car ownership is not expected to change much over time, I chose to fix this variable over time using the 2019 data. The car ownership variable was used because the use of carsharing is highly substitutional for private ownership (Hu et al., 2018; Wang et al., 2012). Not having a private vehicle available is however not seen as an important reason to choose scooter or bike sharing (Aguilera-García et al., 2020; Fishman, 2016). Scooter- and bike sharing are more complementary, where carsharing is substitutional for vehicle ownership. Because of this complementary nature, it is not to be expected that vehicle ownership affects bike- and scooter sharing much. Therefore, the length of bicycle lanes per squared kilometer of each municipality was included as a proxy for 'cyclist-friendliness'. Because both scooters and bikes make use of bicycle lanes in the Netherlands, cyclist-friendliness was included as the control variable. CBS data on bicycle lanes and surface area was used and fixed for the year 2019 while both did not vary much over time (CBS, 2021b).

Operationalization table 1 presents all variables that were used in the analyses and shows how the concepts were converted into measurable quantities. Additionally, table 1 provides the references from where the data was retrieved.

TABLE 1. OPERATIONALIZATION TABLE

| Variable | Concept | Indicators | Measurement scale | Source |
|---|---|---|---|---|
| | | DEPENDENT VARIABLE | | |
| **First introduction (event)** | First introduction in a municipality at a specific point in time | Does mobility market A in municipality *i* experience an introduction at time *t*? | Binary:<br>No (0)<br>Yes (1) | Appendix A.2, A.3 and A.4 |
| | | INDEPENDENT VARIABLES – explanatory | | |
| **Presence mobility type B** | Presence of another mobility type | Was there a OWBM present in city *i* in mobility market B before time *t*? | Binary:<br>No (0)<br>Yes (1) | Datasets of other mobility types (appendices A) |
| **presence mobility type C** | Presence of another mobility type | Was there a business model present in city *i* in mobility market X2 at time *t*? | Binary:<br>No (0)<br>Yes (1) | Datasets of other mobility types (appendices A) |
| | | INDEPENDENT VARIABLES – control | | |
| **Car ownership** | Car ownership | Average number of cars per household | Cars per households | CBS (2021a) |
| **Bicycle-friendliness** | Bicycle-friendliness | Kilometres bike lane per surface area | Km bike lane per $km^2$ of the municipality | CBS (2021a), CBS (2021b) |
| **Public transport** | Proximity to train station | Average distance to train station | Kilometer to train station | CBS (2021a) |
| **Surface area** | Surface area | Total surface area of the municipality | Squared kilometers surface area | CBS (2021a) |
| **Income** | Income | Average income per capita | Gross average income per capita in Euro | CBS (2021a) |
| | | INDEPENDENT VARIABLES – demographics | | |
| **City size** | Population size | Number of people living in municipality | Inhabitants (per 10,000 population) | CBS (2021a) |
| **Population density** | Population density | Number of people per surface area | Inhabitants per $km^2$ (per 100 population) | CBS (2021a) |

| | | | | |
|---|---|---|---|---|
| **Household composition** | Household size | Average number of people per household | People per household | CBS (2021a) |
| **Demographic pressure** | Working population | Non-working population relative to working population | Sum of people between under 20 and over 65 years old divided by sum of people between 20 and 65 years old | CBS (2021a) |

## 3.5 DATA ANALYSIS AND REGRESSION

The research employs a time-to-event model to measure the time between business model introductions in municipalities in the dataset. Time-to-event analysis is a popular type of analysis for epidemiologic data that is used in medical and biological research, were its often referred to as survival analysis (Kleinbaum & Klein, 2012; Liu, 2012). However, the analysis is also used in social sciences for time-to-event processes (Liu, 2012). The survival model is applicable for studying the impact of time-varying covariates on the risk of the occurrence of a specific event, in the case of this research the local introductions of OWBMs. Some variations on the survival model exist (Kleinbaum & Klein,2012), but the Cox proportional hazard model fits to the research because it considers the right-censored nature of the data. That is, it accounts for the municipalities that did not experience an introduction in the studied period but may experience an introduction somewhere in the future.

Because the time-varying independent variables are used, the Cox model does not longer satisfy the PH assumption and therefore the extended form of the Cox model must be used (Kleinbaum & Klein, 2012). To estimate coefficients for the independent variables associated with the risk of introduction, the extended Cox model uses an exponential hazard function to estimate the risk that if at time *t* a municipality has not seen an introduction of the OWBM, the municipality will experience an introduction in the next moment. The data is arranged in such a way that each municipality contributes a row for each time interval, making it possible for the time-dependent variables to change (Kleinbaum & Klein, 2012). The extended Cox proportional hazard model is mathematically explained as:

*(1)*

$$h(t, X(t)) = h_0(t)\, exp\left[\sum_{i=0}^{p1} \beta_i X_i + \sum_{j=0}^{p2} \beta_j X_j\,(t)\right]$$

Where h(t, X(t)) is the expected hazard at time *t* for all predictors. Note that this hazard is not satisfied in the extended model and therefore not used. $h_0$ (t) is the baseline hazard and represents the hazard when all hazards are equal to zero. $X_i$ is a vector of non-time-varying independent variables (urbanity and control variables), $X_j$ is a vector of time-varying independent variables (introductions of other mobility types) and $\beta_i$ and $\beta_j$ are vectors of regression coefficients. The R package *survival* was used to estimate the models (Therneau, 2018). The R code is provided in appendix C2 to C4.

The regressions were applied on each vehicle sharing type: car, scooter and bicycles. Four dependent variables were formatted for each analysis to determine the expected survival time: (1) id (2) start time, (3) stop time and (4) event. 'id' is a unique identification number assigned to each municipality. To determine the interval until the next event, the variables 'start time' and 'stop time' were established. Start time is the stop time of the previous introduction, in another municipality. Stop time is the month in which an introduction occurs, in municipality *i*. The interval between these two thus determines the time to the event of a business model introduction in one municipality until an introduction in the next municipality. The dummy variable 'event' was assigned 1 when a business model was introduced in municipality *i* at time *t,* and zero otherwise. A zero before the end of the study period indicates no introduction has occurred yet in municipality *i* and a zero at the end of the study period indicates the censored observations - i.e., the municipalities where no introduction occurs at all in the given time frame.

To test the robustness of the models, either the Wald test or log-likelihood ratio test can be used but result in the same conclusions (Kleinbaum & Klein, 2012). The log-likelihood ratio test was chosen to assess the goodness of fit between two models based on the ratio of their likelihood. Function 2 provides the formula for the test where $loglik(m_x)$ denotes the model that needs to be compared. To measure model improvement the log-likelihood ratio was calculated for the different nested models:

*(2)*

$$LRR = -2\left[\left(loglik(m_n)\right) - \left(loglik(m_x)\right)\right]$$

where $m_n$ denotes the model that is compared to and $m_x$ denotes the model of which the likelihood ratio is tested.

## 3.6 Research quality

The research methods are replicable while the raw data from appendix A can be constructed in a similar manner due to the wide availability of new articles. Outside of the Netherlands the methods would be applicable in a similar way. The official statistics that were included offer reliable and replicable data. A risk within the chosen methods is that essential data overlooked during data collection. For instance, when a business model entry in a certain municipality is not recorded by the researcher. To prevent such missing data, targeted search methods were used in several search engines (see data collection) to prevent data from missing. However, the methods do not guarantee that all desired data can be collected, and thus the measurement does not always entirely reflect the concept that is studied. For this study, business model introductions could be overlooked, especially those offered by small providers operating in only one city. Cykl for example, is a minor pilot in Wageningen, offering only very few bikes and was found by coincidence rather than the used methods.

The time-varying covariates used in the Cox regression allows for causal inferences to be made – i.e. the study predicts the likelihood of business model introductions in municipalities over time. Also, the Cox model considers censored data, that is, the model takes into account all the events, even if they were not observed within the same period and even if the event did not take place before the end of the survey (Bugnard et al., 1994). This is particularly an advantage for small datasets and allows to study emerging phenomena, such as the introduction of OWBMs. However, it should be noted that empirical results that support imitation does not automatically prove causality. The research suggests that x causes y – i.e. OWNM presence causes OWBM introduction, but can we really certain that the studied phenomenon is caused by what is suggested? This issue is described as internal validity (Brymann, 2016). To strengthen the argument for causality, control variables were selected based on their association with the use and presence of vehicle sharing platforms. Such variables are not of interest for the outcome of the study but increase internal validity by limiting the effect of confounding and other extraneous variables (Bhandari, 2021).

The study period is relatively short for studying diffusion and would ideally have been longer. Especially because vehicle sharing business models are emerging only recently on a more frequent basis, not much activity has been registered in the first years during the study period. While no longer time frame could be considered, this might be a weaker property of the data in light of representativeness. Also, because the studied phenomena are novel, the dataset presents most of the events ever occurred in the Netherlands and therefore is quite complete. Finally, the phenomenon of vehicle sharing is unlikely to be feasible to study for a longer period of time elsewhere. Therefore, the observation time of ten years seems reasonable and should be sufficient to potentially make a meaningful contribution to the literature.

Finally, the sample was taken from one country, the Netherlands. To what extent the results are generalizable to other countries and their cities, is not straightforward. While many different cities were included in the sample, variation was accounted for, however, when more countries and their cities are included in the sample, results may differ because of the structural differences these cities could have in comparison to Dutch cities.

# 4. RESULTS

## 4.1 DESCRIPTIVE STATISTICS

The descriptive statistics of the three separate analyses are discussed together in this subsection. Figures 3 and 4 visualize how the examined business models were introduced over time. The descriptive statistics are displayed in table 2. Figure 5 presents the spatial distribution of the presence of OWBMs at the end of the study period.

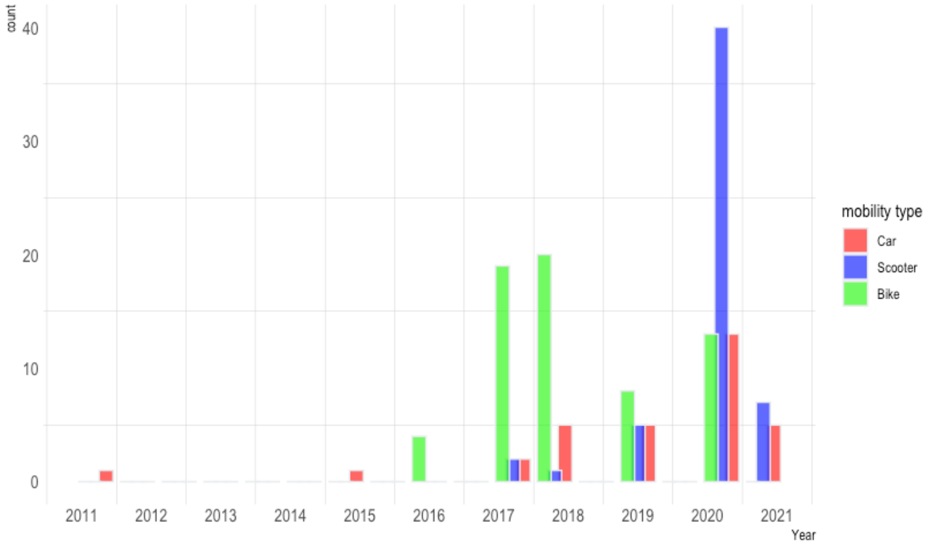



FIGURE 3. INTRODUCTIONS OF VEHICLE SHARING BUSINESS MODELS IN THE NETHERLANDS PER MOBILITY TYPE
*2021 results from data from Jan – March and therefore does not represent the whole year

Between 2011 and March 2021, 151 OWBMs were introduced in the Netherlands. Figure 3 displays all business model introductions that were found, and thus includes both initial and following introductions. The figure shows how these introductions were distributed over the years, subdivided in the three types of shared mobility. Bike sharing experienced the most introductions, with a total of 64, peaking in 2017 and 2018. Scooter sharing stands out in 2020 and can be accounted for by the rapid, currently ongoing, growth of the three scooter sharing firms that are active in the Netherlands: Felyx, Check and Gosharing (Kuijpers, 2020). Carsharing experienced the least introductions but was nevertheless the first mobility type to establish itself and seems to be growing in recent years. While most introductions occurred in 2020, 2021 shows to be a promising year to continue the trend.

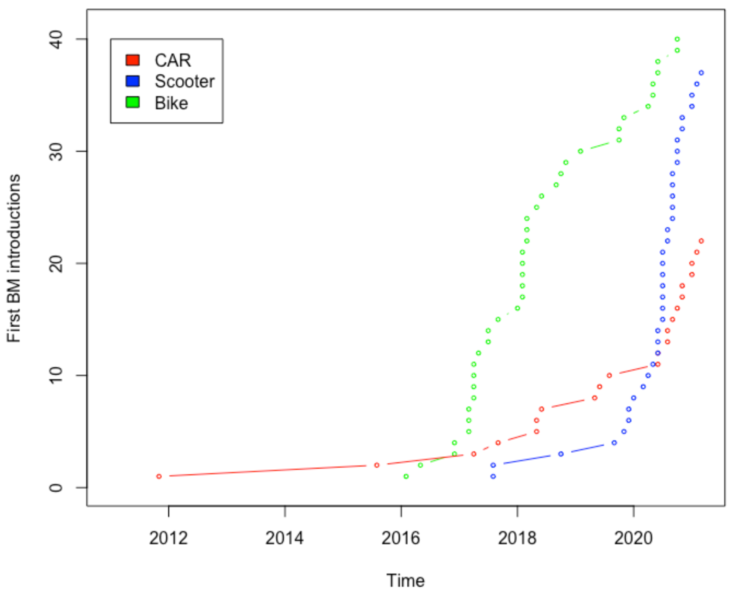



FIGURE 4. INITIAL INTRODUCTIONS OF VEHICLE SHARING BUSINESS MODELS IN THE NETHERLANDS PER MOBILITY TYPE

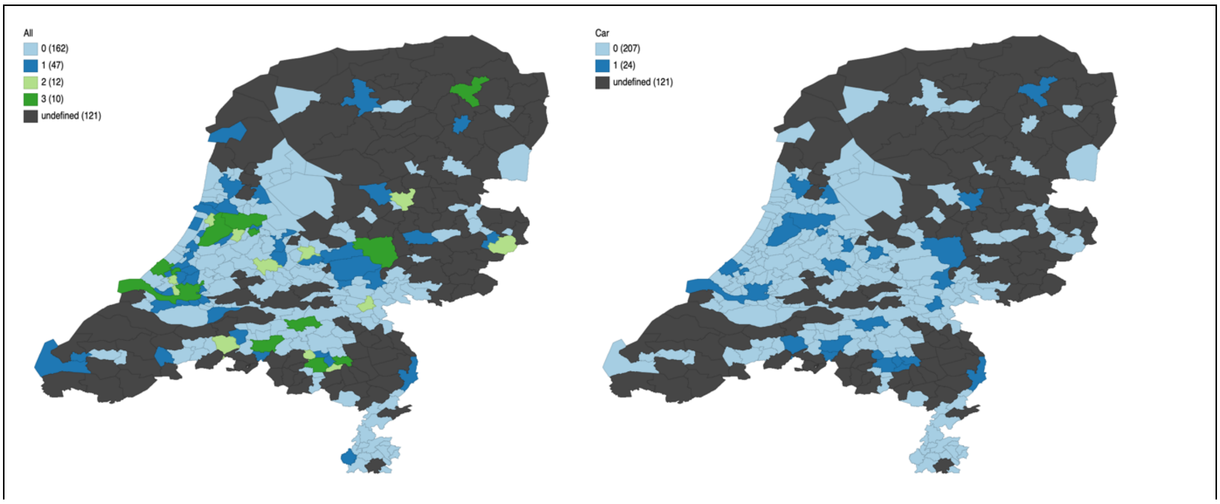
Figure 4 displays only the initial introductions for each of the three mobility types over time. Not surprising, the statistic shows a similar pattern as Figure 3. Bike sharing OWBMs first start to emerge in 2016 and increase gradually, car sharing's first models appear early, but only gain momentum at the end of the study period and scooter sharing shows a rapid growth at the end of the study period. The statistic provides insight in the moment in time where one mobility type surpasses the other in terms of number of initial business model introductions at the intersection points of the graph. Scooter sharing takes off very late in the study period but surpasses carsharing somewhere mid 2020. Also, the recent growth of scooter sharing business model introductions made scooter approach bike sharing and may surpass the number of bike sharing business models in the near future at this rate. Therefore, one-way scooter sharing might be present in more municipalities in the Netherlands than any other form of one-way vehicle sharing within a few years. Carsharing has also been growing rapidly since 2020 and may also be in the race to be introduced in many municipalities in the Netherlands. Because this recent growth can be accounted for mostly by one service named Amber (see appendix A1 and A2), it remains unclear whether other existing or new services will expand in the Dutch market.

Table 2 shows the descriptive statistics for the regression with 232 observations (N) for each variable that was used in the regression. The mean indicates that the average municipality within the dataset has a population density of 1,204 people per squared kilometer and 55,500 inhabitants (population density was measured per 100 and population size per 10,000 inhabitants). Large differences exist between the urbanity of municipalities, as the smallest town included hosts less than 10,000 inhabitants and the largest city is populated by over 870,000 people. Also, the population density varies between 300 and 6,600 inhabitants per squared kilometer. These are not random outliers as the standard deviation exceeds the mean for both variables. The average household owns 1.05 cars with a remarkable minimum of only 0.44 per household. This may be the result of a few large cities where car ownership is scarce, and households are smaller on average. The mobility type variables (car, scooter and bike) are based on binary data and therefore the vary between 0 and 1. One in ten municipalities in the dataset experienced an initial introduction of the OWBM for carsharing and 16 and 18 percent of the municipalities experienced such an introduction for scooter and bike sharing respectively.

TABLE 2. DESCRIPTIVE STATISTICS

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| Population.density | 232 | 12.04 | 11.40 | 3 | 66 |
| Population.size | 232 | 5.55 | 8.80 | 0 | 87 |
| Public.transport | 232 | 4.87 | 4.21 | 1.00 | 27.40 |
| Household.size | 232 | 2.24 | 0.18 | 1.69 | 3.30 |
| Surface.area | 232 | 73.96 | 81.13 | 7.84 | 765.45 |
| Demographic.pressure | 232 | 75.98 | 9.04 | 46.60 | 113.00 |
| Income | 232 | 44.88 | 8.12 | 0.00 | 78.00 |
| Cyclist.friendliness | 232 | 6.62 | 3.37 | 0.38 | 18.14 |
| Car.ownership | 232 | 1.05 | 0.16 | 0.44 | 1.37 |
| Car | 232 | 0.10 | 0.31 | 0 | 1 |
| Scooter | 232 | 0.16 | 0.37 | 0 | 1 |
| Bike | 232 | 0.18 | 0.38 | 0 | 1 |

Figure 5 visualizes the municipalities in which OWBM have been introduced in the Netherlands. The map at the top left corner counts all initial OWBM introductions that have occurred between 2011 and March 2021 for the three mobility types combined. Thereafter, maps for car, scooter and bike introductions are presented separately. The black areas present municipalities that were excluded from the dataset because these did not meet the criteria for being urban. The light blue areas represent municipalities that were included in the data but did not experience an introduction of the OWBM for the respective mobility type. Dark blue areas experienced one introduction in that municipality. In the first map that counts introductions of all mobility types, light green presents municipalities where two mobility types are present and dark green where all three are present. The presence of OWBMs is concentrated around the west coast and center of the Netherlands. This is an area known as the "Randstad" which is considered the most urban area in the Netherlands. Remarkable is that carsharing seems most scattered across the country while scooter and bike sharing are more clustered. These clustered result in a high concentration of OWBMs in the province Brabant and around the cities of Rotterdam, The Hague and Amsterdam. The clustering of scooter models can be explained by the expansion pattern of scooter sharing platforms as they generally start off in a large city and expand toward the surrounding municipalities creating one large service area. Looking at Figure 5, some sort of local imitation can be proposed. First, as 12 and 10 municipalities respectively have two and three mobility types already, this could indicate local imitation. Also, the clustering around metropolitan areas suggest that imitation could occur within these regions.



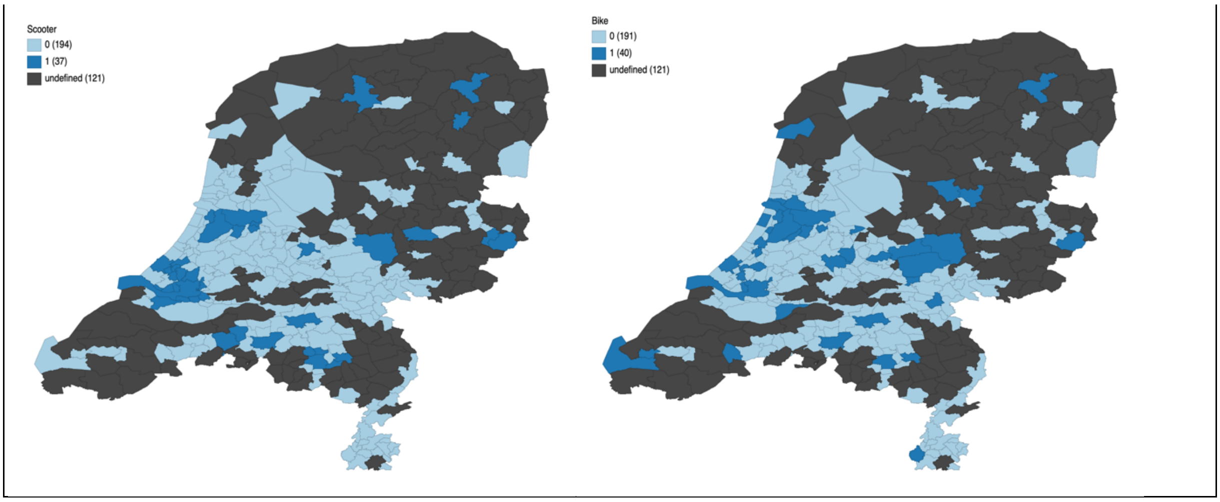



FIGURE 5. SPATIAL DISTRIBUTION OF ONE-WAY VEHICLE SHARING IN THE NETHERLANDS AT THE END OF THE STUDY PERIOD

## 4.2 REGRESSION RESULTS

Before including the variables in the regression, correlations between the independent variables were inspected in a linear setting. Generally, a correlation between two variables is considered to severely distort a model at a threshold of 0.7 (Dormann et al., 2013). A strong correlation of 0.86 was observed between cyclist friendliness and population density (appendix B), therefore, these variables will not be used in the same model. The other correlations were found to be low to moderate (Appendix B).

For each mobility type, the survival analysis is presented separately. The analyses each use six models. First, the urbanity model is presented, which uses four covariates that are not time-varying to make a prediction that supports or rejects hypothesis 4 and 5. Second, the null model includes only the control variables of the imitation analysis, thereafter various explanatory variables are added in model 3, 4 and 5. These models aim to test hypotheses 1 to 3. Finally, model 6 includes all covariates to compare the urbanity and imitation model.

The regression results report the exponentiated coefficients, to indicate the effect of the independent variables on the dependent variables (positive or negative). The effect of the independent variables can be interpreted as the percentage change in hazard rate due to a marginal change, when all other variables are unchanged (Blossfeld et al., 2019). A coefficient of 0.5 can thus be interpreted as a 50 percent decrease in hazard rate from a one-unit change. A coefficient of 1.5 can be interpreted as a 50 percent increase in hazard rate from a one-unit change. The values behind the coefficients between brackets denote the standard deviation. We should be careful with interpreting these coefficients however, as a one-unit change in for instance population size is not comparable with a one-unit change in the presence of a business model. The impact of such a change of an explanatory variable may be much larger than the impact of a one-unit change of other variables, due to the relative size of a one-unit change. Additionally, the log-likelihood of the nested models is compared to the null model using the likelihood ratio test. This allows for a comparison between the models. The model that makes the data most likely maximizes the log likelihood function.

### *4.2.1 MOBILITY TYPE 1 – CARSHARING*

Table 3 shows the exponentiated coefficients for the Cox regressions that were used for the carsharing analysis. First, the demographics model shows significant effects on population size and population density. The effect on population size is 21 percent, indicating that an increase of 10,000 inhabitants within any municipality makes it 21 percent more likely that this municipality will be subjected to an introduction of the carsharing OWBM in the next instant. The coefficient for population density shows a remarkable result, as the hazard rate decreases with an increase of 100 inhabitants per km$^2$. This result is unexpected but could be caused by some smaller carsharing providers that operate with few cars in smaller towns. A rival explanation could be that some cities have very densely populated areas were the carsharing services operate, but also recreational areas that are spacious, decreasing the average population density of the city.

The models used to measure local imitation (2 to 5) show significant coefficients for the car ownership covariate which has a negative effect on the on the likelihood of experiencing an introduction of one-way carsharing business model. The effect of car ownership decreases the hazard rate with more than 99 percent for a one-unit increase of the average number of cars owned per household. This means the more cars people own within a municipality, the less likely it is for a one-way carsharing business models to be introduced in that municipality in the next instant. More precisely, if people households in a municipality would own two cars instead of one, the introduction of one-way carsharing would 99 percent less likely. This is an expected effect, as carsharing is substitutional to car ownership (Hu et al., 2018; Wang et al., 2012). Surface area shows a positive effect on the dependent variable in model 2 to 5, indicating that the more spacious a municipality is, the more likely it is for an introduction to occur. This effect is rather weak however, as the mean of the surface area variable is 74 km$^2$ the increase of hazard rate is only 0.4 to 0.5 percent.

The coefficient for the explanatory scoote variable shows a positive estimated effect on the hazard rate with a significance level of 0.01 in model 3 and 5. The hazard rate increases with 863 to 869 percent with a marginal increase in the scooter sharing variable. A marginal increase in the scooter sharing variable is equivalent to an increase of 1 scooter OWBM being present in a municipality before one-way carsharing is introduced. No significant evidence was found for the presence of OWBMs of bike sharing to attract the introduction of OWBMs of carsharing. While the effect was not significant, the effects that was measured in models 4 and 5 were much smaller than that of the scooter sharing variable.

TABLE 3. COX REGRESSION RESULTS CARSHARING ANALYSIS

| | (1) Demographics | (2) Null.model | (3) Scooter | (4) Bike | (5) Scooter.and.bike | (6) Combined |
|---|---|---|---|---|---|---|
| Demographic.pressure | 0.924 | | | | | 0.923 |
| | (0.045) | | | | | (0.058) |
| Population.size | 1.210*** | | | | | 1.222** |
| | (0.047) | | | | | (0.070) |
| Household.size | 0.103 | | | | | 0.462 |
| | (1.794) | | | | | (3.703) |
| Population.density | 0.920* | | | | | 0.880* |
| | (0.035) | | | | | (0.061) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Scooter | | | $9.634^{**}$ | | $9.691^{**}$ | $5.575^{*}$ |
| | | | (0.766) | | (0.755) | (0.803) |
| Bike | | | | 2.036 | 2.094 | 0.810 |
| | | | | (0.634) | (0.605) | (0.720) |
| Income | | 1.000 | 1.006 | 1.006 | 1.011 | 1.073 |
| | | (0.052) | (0.054) | (0.054) | (0.055) | (0.084) |
| Car.ownership | | $0.001^{***}$ | $0.003^{***}$ | $0.003^{***}$ | $0.008^{**}$ | 0.068 |
| | | (1.430) | (1.595) | (1.672) | (1.771) | (5.013) |
| Public.transport | | 0.944 | 0.943 | 0.941 | 0.938 | 0.890 |
| | | (0.109) | (0.114) | (0.115) | (0.123) | (0.153) |
| Surface.area | | $1.004^{**}$ | $1.005^{**}$ | $1.004^{**}$ | $1.005^{**}$ | 0.995 |
| | | (0.001) | (0.001) | (0.001) | (0.002) | (0.007) |
| Observations | 3,982 | 3,982 | 3,982 | 3,982 | 3,982 | 3,982 |
| Number of events | 17 | 17 | 17 | 17 | 17 | 17 |
| LLR-test | 36.27 | | 9.19 | 1.24 | 10.69 | 43.32 |
| compared to | null model | | null model | null model | null model | null model |
| *Note:* | | | | | | $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$ |

The effect of one-way scooter sharing proved to be significant in model 6, however with a smaller positive effect and a lower significance level than in model 3 and 5. The models suggests that scooter sharing OWBMs attract carsharing OWBMs. Therefore, hypothesis 1 can be partially supported by these results. It can be said that the presence of one-way scooter sharing attracts one-way carsharing to municipalities. The combined model shows to be the best fit as it has the highest relative log-likelihood ratio. Thereafter, the urbanity model best predicts the dependent variable, as the LLR-test is 36.33 compared to the null model. The urbanity variables thus have a large share in the explanatory power of model 6.

### *4.2.2 Mobility type 2 – Scooter sharing*

Table 4 shows the exponentiated coefficients for the Cox regressions that were used for the scooter sharing analysis. The demographics model shows a positive effect on the hazard rate of 9.5 percent, indicating a dependence of one-way scooter sharing on populations size. This effect is smaller than the measured effect in the carsharing analysis. Therefore, scooter sharing is less influenced by population size compared to carsharing.

Cyclist-friendliness has a positive effect on the hazard ratio. This indicates that for every extra kilometer bicycle lane there is in a municipality per squared kilometer, the hazard of an introduction in the next instance increases with 24 to 31 percent, depending on the model that is chosen. The more hospitable a municipality is towards scooter in terms of offering bicycle lanes, the more likely it is for scooter sharing to be introduced in that municipality. Surface area shows similar results as the carsharing analysis; it has a small positive effect on the hazard rate. The regression coefficients of the explanatory variables in model 3 to 5 show positive and significant effects on the introduction of scooter OWBMs. The regression coefficients for the explanatory variables denote an increase in hazard rate of one-way scooter model introduction between 382 and 400 percent for one-unit change in these variables. Model 5 shows that the effects of the car- and bike sharing in the same model decrease but still have a significant effect. Scooter sharing business models emerged only recently while car and bike sharing emerged earlier in the past decade in Dutch municipalities, which could explain the attractive effect of both car- and bike sharing on scooter sharing.

TABLE 4. COX REGRESSION RESULTS SCOOTER SHARING ANALYSIS

| | (1) Demographics | (2) Null.model | (3) Car | (4) Bike | (5) Car.and.bike | (6) Combined |
|---|---|---|---|---|---|---|
| Demographic.pressure | 0.970 | | | | | 0.964 |
| | (0.041) | | | | | (0.043) |
| Population.size | 1.095** | | | | | 1.124* |
| | (0.029) | | | | | (0.048) |
| Household.size | 1.158 | | | | | 1.598 |
| | (1.720) | | | | | (2.034) |
| Population.density | 1.025 | | | | | 1.004 |
| | (0.022) | | | | | (0.028) |
| Car | | | 5.404** | | 3.410* | 0.297 |
| | | | (0.553) | | (0.583) | (1.125) |
| Bike | | | | 4.824** | 3.756* | 2.230 |
| | | | | (0.527) | (0.557) | (0.678) |
| Income | | 0.995 | 1.007 | 1.016 | 1.020 | 1.031 |
| | | (0.039) | (0.042) | (0.046) | (0.046) | (0.063) |
| Cyclist.friendliness | | 1.303*** | 1.307*** | 1.240*** | 1.244** | |
| | | (0.061) | (0.067) | (0.062) | (0.068) | |
| Public.transport | | 0.854 | 0.890 | 0.895 | 0.912 | 0.898 |
| | | (0.128) | (0.127) | (0.136) | (0.133) | (0.128) |
| Surface.area | | 1.006*** | 1.006** | 1.006** | 1.005* | 0.998 |
| | | (0.002) | (0.002) | (0.002) | (0.002) | (0.005) |
| Observations | 4,091 | 4,091 | 4,091 | 4,091 | 4,091 | 4,091 |
| Number of events | 17 | 17 | 17 | 17 | 17 | 17 |
| LLR-test | 19.01 | | 7.28 | 9.09 | 12.96 | 23.02 |
| compared to | null model | | null model | null model | null model | null model |
| *Note:* | | | | *p<0.05; **p<0.01; ***p<0.001 | | |

Hypothesis 2 is supported, as the presence of both car- bike sharing can explain the location of introduction of one-way scooter sharing business models in Dutch municipalities. Model 6 has the largest log-likelihood ratio of all models, making the data most likely. However, no significant effects could be determined for the explanatory variables, leaving the support for hypothesis 2 with a degree of uncertainty. The demographics model has the largest log-likelihood making this data more likely compared to model 2 to 5.

### 4.2.3 Mobility type 3 – Bike Sharing

Table 5 shows the exponentiated coefficients for the Cox regressions that were used for the bike sharing analysis. The demographics model shows significant coefficients for demographic pressure and population density. Demographic pressure was also found to be significant with a decrease in hazard rate of 6 percent. This means that with an increase of working population relative to the non-working population, the likelihood of an introduction of one-way bike sharing increases. This is an expected effect, as vehicle sharing is expected in locations with a high proportion of working population. The population density variable shows a positive effect on the hazard rate with 4 percent, meaning the likelihood for a bike sharing OWBM to be introduced increases with every 100 extra inhabitants per km$^2$. For population size no significant result was found. However, the increase in hazard rate was found to be of a lesser magnitude than for the car- and scooter sharing analyses.

Cyclist-friendliness has a positive effect on the hazard ratio. This indicates that for every extra kilometer bicycle lane there is in a municipality per squared kilometer, the hazard of an introduction in the next instant increases with 23 to 29 percent, depending on the model that is chosen. This is an expected effect; the more hospitable municipalities to cyclists, the more likely they are to attract bike sharing services. Surface area shows a similar small increase in hazard rate as for the car and scooter sharing analysis and can be interpreted in a similar fashion: the larger a municipality, the more likely an introduction of a bike sharing OWBM at the next instant. The increase in hazard rate that results from a marginal increase in the scooter sharing variable is between 745 and 809 percent in model 3 and 5. A marginal increase in the scooter sharing variable denotes an increase of one scooter OWBM being present in a municipality before OW carsharing is introduced. An introduction of one-way bike sharing is thus more likely to occur in the next instant because of the presence of a scooter OWBM. While the effect of the explanatory variable for carsharing was not significant, the measured effect is weaker than the effect of the scooter variable.

Table 5. Cox regression results scooter sharing analysis

| | (1) Demographics | (2) Null.model | (3) Scooter | (4) Car | (5) Car.and.scooter | (6) Combined |
|---|---|---|---|---|---|---|
| Demographic.pressure | 0.938* | | | | | 0.940* |
| | (0.032) | | | | | (0.031) |
| Population.size | 1.006 | | | | | 0.992 |
| | (0.015) | | | | | (0.022) |
| Household.size | 0.183 | | | | | 0.122 |
| | (1.525) | | | | | (1.714) |
| Population.density | 1.039* | | | | | 1.037* |
| | (0.015) | | | | | (0.018) |
| Scooter | | | 9.093*** | | 8.453** | 4.910* |
| | | | (0.641) | | (0.707) | (0.720) |
| Car | | | | 3.287 | 1.248 | 0.594 |
| | | | | (0.758) | (0.890) | (1.065) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Income | | 0.980 | 0.983 | 0.981 | 0.983 | 1.036 |
| | | (0.027) | (0.029) | (0.028) | (0.029) | (0.050) |
| Cyclist.friendliness | | $1.292^{***}$ | $1.226^{***}$ | $1.285^{***}$ | $1.226^{***}$ | |
| | | (0.054) | (0.058) | (0.055) | (0.058) | |
| Public.transport | | 0.907 | 0.901 | 0.912 | 0.901 | 0.947 |
| | | (0.083) | (0.086) | (0.083) | (0.086) | (0.078) |
| Surface.area | | $1.006^{***}$ | $1.005^{**}$ | $1.005^{***}$ | $1.005^{**}$ | $1.004^{*}$ |
| | | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Observations | 5,447 | 5,447 | 5,447 | 5,447 | 5,447 | 5,447 |
| Number of events | 17 | 17 | 17 | 17 | 17 | 17 |
| LLR-test | 11.64 | | 1.84 | 9.8 | 9.86 | 19.78 |
| compared to | Null model | | null model | null model | null model | null model |
| *Note:* | | | | | | $^{*}$p<0.05; $^{**}$p<0.01; $^{***}$p<0.001 |

Hypothesis 3 is partially supported, as one-way bike sharing was found to be attracted by one-way scooter sharing but not in a significantly by OW carsharing. The log-likelihood ratio test shows that the combined model best explains the data, and the scooter variable is still significant. While the effect of scooter presence gets weaker, the hazard rate still increases with 391 percent in model 6 due to one-unit increase in the scooter presence variable.

#### 4.2.4 DEMOGRAPHIC CITY CHARACTERISTICS

The regression results suggest that the demographic factors that were use have some effect on location choice of one-way vehicle sharing companies. Car and scooter sharing depend to some extent on population size and bike- and car sharing depend on population density however, population density was found to have a negative effect on carsharing. Also, demographic pressure was found to affect the location choice of one-way bike sharing platforms. These results suggest that the three types of one-way vehicle sharing depend to some extent on demographic city characteristics, however, stronger evidence was expected. Overall, hypothesis 4 can only be partially confirmed.

For the degree to which the different mobility types depend on demographic city characteristics mixed results were found. As car- and bike sharing showed very different effects on the hazard rate for the population density variable and no significant effect was found for this variable in the scooter analysis, no pattern could be observed. The effect of population size showed to decrease over the analyses, therefore associating carsharing most with population size and bike sharing least. However, since the population size coefficient for bike sharing was not significant, no certain pattern was found. Therefore, no clear evidence was found for a different degree of dependence on demographic city characteristics and therefore can hypothesis 5 not be confirmed.

# 5. CONCLUSIONS

This paper studied the factors that are associated with the location choice of one-way vehicle sharing platforms in the Netherlands. As vehicle sharing requires a certain level of urbanity to flourish, we expect vehicle sharing platform companies to consider such urban factors in their location decisions. The research first investigates the extent to which three different types of vehicle sharing, namely: car-, scooter- and bike sharing, are dependent on demographic city characteristics. Moreover, the extent to which vehicle sharing platforms' location decisions are affected by the local presence of vehicle sharing business models in related mobility markets was subjected to research. This process was defined as 'local imitation' and was theorized to be motivated by three sorts of changes in the local institutional context: localized knowledge spillovers, regulatory change and change in consumer behavior.

First, demographic city characteristics were considered as factors that affect the location choice of vehicle sharing platforms. The findings suggest that population size affects the different types of vehicle sharing in the following way: one-way carsharing is most dependent on a high population size, while scooter sharing is less dependent on population size. For bike sharing no conclusions could be drawn regarding population size. Population density had an unexpected effect on one-way carsharing: a high population density was found to be negatively associated with one-way carsharing, while we would expect that dense cities would attract carsharing. A high population size was found to encourage the location choice of one-way bike sharing on the other hand. Finally, the demographic pressure of a city influences bike sharing as well, as cities where the working population is relatively high attract one-way bike sharing. Altogether, the finding indicate that one-way vehicle sharing s to some extent dependent on demographic city characteristics, but no substantial difference was found amongst the different mobility types.

Second, the research uses a theory of local imitation to contribute to the understanding of the location choices of platform companies on a city-level. The aim was to comprehend the reasons behind the location choices of vehicle sharing platforms for municipalities in the Netherlands. The research specifically studied why three mobility modes of one-way vehicle sharing platforms favor one municipality over another in their location choices. Imitation was associated as the main driver for location decisions of vehicle sharing companies. These imitation processes were theorized on a local level, leading to the concept of 'local imitation': a process where business models are imitated within a municipal jurisdiction across related markets. The imitation process is suggested to be driven legitimacy that is created by the introduction of business models in related markets within a municipality. The creation of legitimacy for vehicle sharing platforms is governed by institutional factors, that are shaped by the local market entrance of platform companies. Vehicle sharing platforms were suggested to be tied stronger to their location than many other digital platforms. These location-bound platforms are affected more by local institutions compared to platforms that are not tied to geographical locations. Therefore, studying vehicle sharing platforms can further the understanding of location-bound platforms and their interplay with local institutions.

Indicative evidence was found for local imitation between one-way mobility business models. The analyses confirmed the possibility of local imitation between the different mobility types of one-way vehicle sharing. The first analysis concludes that one-way carsharing is attracted by one-way scooter sharing, the second analysis concludes that scooter sharing is attracted by both one-way car- and bike sharing, and the third analysis found evidence for scooter sharing to attract one-way bike sharing. The evidence thus suggests that the location choice of one-way vehicle sharing companies is affected by the local presence of one-way business models in related markets. Therefore, it can be said that one-way business models attract each other to their geographical locations.

# 6. Discussion, limitations and future research

## 6.1 Discussion

Early research on vehicle sharing has mainly been concerned with either a single mobility mode (e.g. Münzel, 2020; Ma et al, 2018; Kortum et al, 2016), shared mobility as a whole (e.g. Machado et al, 2018; Laporte et al, 2015; Shaheen et al, 2015) or the conceptual frameworks of its business models (e.g. Shaheen & Chan, 2016). Consequently, the markets of vehicle sharing were never compared in an empirical setting within the same study. This research answers the call of Münzel (2020) by researching other shared mobility forms than carsharing and the diffusion of their business models. The three different mobility markets that were studied, car, scooter and bike, are seen as the three main mobility modes in vehicle sharing (Shaheen & Chan, 2016) and are therefore appropriate markets to study, and reflect on one-way vehicle sharing. Because vehicle sharing consist of different mobility markets in which similar business models are used, taking business models as a unit of analysis allowed for comparing vehicle sharing markets. The study tested to what extent demographic city characteristics influence these different mobility types. As expected, some evidence was found for the one-way vehicle sharing to depend on these urban factors, as the literature suggest different types and forms of vehicle sharing are related to these factors (Shaheen et al., 2021; Kortum et al., 2016; Aguilera-García et al., 2020; Du et al., 2019). This thesis did not reveal new insights about one-way vehicle sharing specifically compared to vehicle sharing as a whole in terms of dependence on city characteristics. However, this study first compared various mobility types of vehicle sharing and confirmed all three depend at least to some extent on demographic city characteristics. Also, some careful assumptions can be made about how different mobility types of vehicle sharing are affected differently by various urban factors. This study found that carsharing is more attracted by highly populated cities than scooter sharing. As the findings reveal an indication for the different types of vehicle sharing to depend on demographic city characteristics to a different degree, it could be interesting and rewarding for future studies to further investigate this matter.

Some studies discuss reasons for vehicle sharing platforms to exist in certain locations (Münzel, 2020; Kortum et al., 2016; Du et al., 2019; Aguilera-Garcia et al., 2020). Münzel (2020) addresses briefly how one shared mobility type can benefit from the presence of another shared mobility type within a city, specifically how bike sharing system can benefit from carsharing systems. However, there is little empirical evidence for local entry decisions of platform companies. The findings of this thesis suggest entry decisions of platform companies are affected by spillover effects and could occur through a process of imitation on a local level across different but related markets. Therefore, the study contributes to the understanding of platforms and their location decisions, in particular the location choices of one-way vehicle sharing that are location-bound.

Previous studies have emphasized the role of the imitation process in the diffusion of business models. Particularly how the success of a business model can motivate other actors to mimic that same practice or business model (Teece, 2010; DiMaggio & Powell, 1983). The present research adds to the understanding of this process by demonstrating that location-bound business models can attract imitators to their location. While it is typically argued that diffusion and the processes by which diffusion is driven in the platform economy are hardly affected by physical distance (Stallkamp & Schotter, 2019), the research concludes some business models of the platform economy are to some extent tied to their location. This may be caused by the nature of these business models, that is that they are location-bound, and therefore are more tied to the local institutions and its related legitimacy.

The findings suggest that scooter sharing is the most dominant actor among the three mobility types. Scooter sharing was found to imitate bike- and carsharing and bike- and car sharing were found to imitate scooter sharing. This could be explained by the late emergence of scooter sharing within the study period. Because many business model introductions of the scooter sharing business model are to be expected in the next years, future studies can provide more insight in imitation processes between vehicle sharing types as it is likely that substantially more useful data will be available in the near future.

## 6.2 POLICY IMPLICATIONS AND SOCIAL RELEVANCE

The attractiveness between vehicle sharing business models brings forward the importance to better integrate the shared mobility system into one cooperative system. Such an integrated mobility system has been studied under the concept of 'mobility-as-a-service' (MaaS) (Akyelken et al., 2018). Urban policy makers should then consider such integration of shared mobility when vehicle sharing emerges in their city. Because vehicle sharing is still a novel phenomenon, and many cities will experience the introduction of its business models in the future, cities should be prepared regarding the policies they design. When the first vehicle sharing platform settles in a city, more will follow as this thesis suggests. Urban policy should be designed in such a way that it fits all vehicle sharing types and it encourages MaaS to develop in cities. Thus, policy makers should not focus much on specific policies for different mobility types and providers but rather create a favorable landscape for all shared mobility business models to develop into an integrated mobility system. Also, providers of different mobility should perhaps be stimulated to cooperate in sharing data to better study the dynamics of the different business models in order to make an integrated shared mobility system possible.

Furthermore, vehicle sharing is said to have positive social and environmental impacts (Shaheen, 2016; Shaheen et al., 2015a). However, only few large cities have a decisive agenda to change the existing regime of vehicle ownership (Gemeente Amsterdam, 2019; Gemeente Utrecht, 2015). While this thesis found that vehicle sharing is present in smaller municipalities as well, their local councils should further explore the possibilities regarding the development of vehicle sharing to reduce environmental and social impacts of traffic and contribute to the sustainable development goals of the Paris Agreement of 2015.

## 6.3 LIMITATIONS AND FUTURE RESEARCH

This thesis explains the location choice of vehicle sharing platforms by a process of imitation. However, the causal relationship between business model presence and introduction is debatable. Internal validity was discussed in the method section: a relationship between x and y does not automatically prove causality. The studied phenomenon could be explained by something that was not considered in the analysis. Because (one-way) vehicle sharing is a new phenomenon, the literate does not provide extensive knowledge about the factors that influence it. A rival explanation would then be concerned with such factors that were not taken into account in the analysis. While variables were constructed to control for the attractiveness of cities, a few unmeasured factors could be thought of. Local institutions within a city could affect the attractiveness for vehicle sharing of a city (van Waes et al., 2020). While this thesis theorizes such institutions are shaped by other vehicle sharing platforms, these institutions could also be influenced by non-vehicle sharing platforms, or institutions could simply inherently differ among cities. Moreover, physical place specific elements, other than proximity to public transport, such as the infrastructure of a city or the location of important hotspots within a city, could explain the location decisions of vehicle sharing companies (van Waes et al., 2020; Shaheen et al., 2021).

Another limitation is concerned with the ongoing development of one-way vehicle sharing. While vehicle sharing has been developing rapidly in the past few years, the study was conducted rather early to produce substantial data on one-way vehicle sharing. The descriptive results that are presented in section 4.1 show that OWBM are introduced at a rapid rate. Therefore, it is presumable that this trend will continue and future research on one-way vehicle sharing in the Netherlands could collect a wider set of data and produce additional and more insightful results.

The study relied on available data from CBS statline. While this data is generally reliable and comprehensive, some variables could not be created because of missing data. Data was not accessible on level of education and parking quality. While most studies that examine vehicle sharing focus on large cities (e.g. van Waes et al., 2020; Kortum et al., 2016), such data is usually available to its researchers. However, in this study, smaller municipalities were included for which this data was missing. Moreover, the research was limited to studying the Netherlands. Including more countries could strengthen the results and deliver more generalizable conclusions. While the Netherlands is a very dense country, it is suitable for studying vehicle sharing, but other countries might inherently differ in terms of spatial composition and density. Therefore, the results of a similar study conducted in a more spacious country could be very different. For instance, that vehicle sharing is not found in smaller municipalities, due to their greater distance to large cities. The present study found that vehicle sharing services often exist in municipalities that are close to each other. In the Netherlands, many sub-urban municipalities lie around cities experience spill overs of vehicle sharing services from the large city which they are near to. To generalize these results, future research should consider other countries than the Netherlands and could investigate the extent to which vehicle sharing services cluster around cities by comparing different countries.

The study found that the large cities have multiple providers of multiple vehicles sharing types. Particularly, scooter sharing platforms emerge quickly and often in the same cities. Also, during data collection, it was noted that some platforms ceased to exist. Some research finds that vehicle sharing, for instance, micro mobility (scooter and bikes sharing amongst others) can be competitive within cities (Reck et al., 2021; Hu & Creutzig, 2021). Therefore, future research could study the survival of vehicle sharing platforms within large cities. To date, it is perhaps early to investigate this, as the development of vehicle sharing is still at its early stages. However, in a roughly a decade, such survival analysis would be interesting to better understand competition between platform companies.

Finally, the generalization of the results to other platform companies is limited. The aim of this study is mostly to say something about location bound business models and vehicle sharing business models specifically. Generalization would then be about the extension of the findings for other platforms that are also location-bound. The study has defined location-bound business models as business models that are strongly bound to their location due to the required capital investments, building of local networks and localized knowledge that is needed to operate. Then what are other industries that employ platforms that are bound to their location in a similar fashion? Few of such platforms exist other than in vehicle sharing, as most platforms other than vehicle sharing do not require as much physical assets, and therefore not large capital investments that are tied to a location. Some platforms other than vehicle sharing platforms are however bound to some extent to their location, for instance: food delivery platforms (Cant, 2019), Airbnb (Zervas et al., 2017) and Uber (Thelen, 2018). These platforms challenge local institution and businesses (Thelen, 2018; Mair & Reischauer, 2017). Future research could investigate how and why some platforms are bound to their location to a greater or lesser extent and develop theories on how these different platforms interact with local institutions.

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# APPENDICES

## APPENDIX A. RAW DATA

### *APPENDIX A.1 FIRMS PER MOBILITY TYPE AND NUMBER OF CITIES OF ACTIVITY*

| Name car sharing firm | Number of cities present | Name scooter sharing firm | Number of cities present | Name bike sharing firm | Number of cities present |
|---|---|---|---|---|---|
| Amber | 22 | Gosharing | 33 | Goabout | 12 |
| Sixt | 3 | Felyx | 17 | UwDeelfiets | 9 |
| Witcar | 3 | Check | 5 | Donkeyrepublic | 7 |
| Fetch | 1 | | | Flickbike | 5 |
| Sharenow (before CAR2GO) | 1 | | | Hopperpoint/bravofiets | 4 |
| Share'ngo | 1 | | | Keobike | 4 |
| | | | | Mobike | 3 |
| | | | | HTM-fiets | 2 |
| | | | | Hellobike | 2 |
| | | | | Vaimoo | 2 |
| | | | | Deelfiets Nederland | 2 |
| | | | | Nextbike | 2 |
| | | | | Dropbike | 1 |
| | | | | oFo | 1 |
| | | | | oBike | 1 |
| | | | | Lime | 1 |
| | | | | Slimonderweg | 1 |
| | | | | Bikeshare050 | 1 |
| | | | | Gobike | 1 |
| | | | | Yobike | 1 |
| | | | | Common.bike/Easyfiets | 1 |
| | | | | Cykl | 1 |

### *APPENDIX A.2 CAR SHARING ALL MARKET ENTRIES*

| Municipality | Name of the service | Entry date (year and month) | Reference(s) | Retrieved on |
|---|---|---|---|---|
| Amsterdam | Sharenow | 01/11/2011 | CAR2GO (2017) | 03/02/2021 |
| Amsterdam | Fetch | 01/01/2019 | Iamsterdam (2018) | 24/02/2021 |
| Amsterdam | Sixt | 01/06/2020 | Van den Boom (2020) | 24/02/2021 |
| Rotterdam | Witcar | 01/08/2015 | van Loo (2015) | 13/02/2021 |
| Rotterdam | Amber | 01/11/2020 | Amber (2020) | 26/04/2021 |
| Rotterdam | Share’ngo | 01/07/2019 | De verkeersonderneming (2019) | 04/03/2021 |
| Rotterdam | Sixt | 01/06/2020 | Van den Boom (2020) | 24/02/2021 |
| S-gravenhage | Sixt | 01/06/2020 | Van den Boom (2020) | 24/02/2021 |
| Eindhoven | Amber | 01/09/2020 | van Neer (2020) | 11/03/2021 |
| Groningen | Witcar | 01/04/2017 | Verkeersnet (2017) | 14/03/2021 |
| Tilburg | Amber | 01/01/2021 | Tilburgnieuws (2021) | 11/03/2021 |
| Utrecht | Amber | 01/05/2018 | Stichtingmilieunet (2018),Amber (2018), Verkeersnet (2017) | 01/04/2021 |
| S-gravenhage | Amber | 01/05/2018 | Stichtingmilieunet (2018),Amber (2018), Verkeersnet (2017) | 01/04/2021 |
| Rotterdam | Amber | 01/05/2018 | Stichtingmilieunet (2018),Amber (2018), Verkeersnet (2017) | 01/04/2021 |
| Amsterdam | Amber | 01/02/2018 | van den Nieuwenhof (2018) | 03/04/2021 |
| s-Hertogenbosch | Amber | 01/02/2021 | Holtermans (2021) | 02/03/2021 |
| Haarlemmermeer | Sixt | 01/06/2020 | Vos (2020) | 03/03/2021 |
| Alkmaar | Amber | 01/11/2020 | Amber (2020) | 26/04/2021 |
| Zwolle | Amber | 01/11/2020 | Amber (2020) | 26/04/2021 |
| Venlo | Amber | 01/08/2019 | Amber (2019) | 02/05/2021 |
| Breda | Amber | 01/10/2020 | internetacrive (2020) | 04/05/2021 |
| Nijmegen | Amber | 01/06/2020 | Amber (2020) | 02/05/2021 |
| Arnhem | Amber | 01/05/2019 | Amber (2019) | 02/05/2021 |

| | | | | |
|---|---|---|---|---|
| Amersfoort | Amber | 01/08/2020 | internetacrive (2020) | 03/05/2021 |
| Apeldoorn | Amber | 01/06/2019 | Amber (2019) | 02/05/2021 |
| Goirle | Amber | 01/01/2021 | Tilburgniuews (2021) | 12/03/2021 |
| Edam-volendam | Witcar | 01/06/2018 | Witcar (2018) | 11/03/2021 |
| Helmond | Amber | 01/09/2020 | internetarchive (2020) | 03/05/2021 |
| Geldrop-Mierlo | Amber | 01/03/2021 | intenetarchive (2021) | 03/05/2021 |
| Nuenen, Gerwen en Nederwetten | Amber | 01/03/2021 | intenetarchive (2021) | 03/05/2021 |
| Best | Amber | 01/09/2017 | van den Nieuwehof (2018) | 03/05/2021 |
| Hilversum | Amber | 01/08/2020 | Internet archive (2020) | 03/05/2021 |

## Appendix A.3 Scooter sharing all market entries

| Municipality | Name of the service | Entry date (year and month) | Reference(s) | Retrieved on |
|---|---|---|---|---|
| Amsterdam | Felyx | 01/08/2017 | Topofminds (2018) | 24/02/2021 |
| Eindhoven | Gosharing | 01/09/2019 | Theeuwen (2019) | 13/03/2021 |
| Groningen | Gosharing | 01/05/2020 | Guit (2020) | 14/03/2021 |
| Rotterdam | Felyx | 01/10/2018 | Putten (2018) | 04/03/2021 |
| The Hague | Felyx | 01/08/2017 | Topofminds (2018) | 24/02/2021 |
| Tilburg | Gosharing | 01/09/2020 | Tilburgnieuws (2020) | 24/03/2021 |
| Amsterdam | Check | 01/09/2020 | Hoogkamer (2020) | 25/03/2021 |
| Eindhoven | Felyx | 01/09/2020 | Micromobiliteit.nl (2020) | 13/03/2021 |
| Groningen | Felyx | 01/06/2020 | Guit (2020) | 14/03/2021 |
| Rotterdam | Check | 01/02/2020 | Van Dijk (2020) | 03/03/2021 |
| The Hague | Gosharing | 01/07/2020 | Der Schrier (2020) | 28/02/2021 |
| Rotterdam | Gosharing | 01/12/2019 | De Kruijff (2019) | 04/03/2021 |
| The Hague | Check | 01/09/2020 | Algemeen dagblad (2020) | 03/03/2021 |
| Breda | Gosharing | 01/06/2020 | Merceleis (2020) | 16/03/2021 |
| Breda | Check | 01/10/2020 | Merceleis (2020) | 16/03/2021 |
| Apeldoorn | Gosharing | 01/11/2020 | Polman (2020) | 16/03/2021 |
| Haarlem | Felyx | 01/11/2020 | Felyx: personal contact by e-mail | 23/03/2021 |
| Haarlem | Gosharing | 01/11/2020 | Haarlemsweekblad (2020) | 16/03/2021 |
| Enschede | Gosharing | 01/07/2020 | Dijkgraaf (2020) | 16/03/2021 |
| Amersfoort | Gosharing | 01/11/2020 | Boone (2020) | 05/03/2021 |
| Haarlemmermeer | Gosharing | 01/01/2021 | Informeer (2021) | 06/03/2021 |
| 's-Hertogenbosch | Felyx | 01/02/2021 | Felyx (2021) | 05/03/2021 |
| 's-Hertogenbosch | Gosharing | 01/07/2020 | Holtermans (2020) | 06/03/2021 |
| Leeuwarden | Gosharing | 01/07/2020 | Omrop Fryslân (2020) | 07/03/2021 |
| Delft | Gosharing | 01/07/2020 | Toetenel (2020) | 15/03/2021 |
| Delft | Felyx | 01/08/2020 | Toetenel (2020) | 15/03/2021 |
| Deventer | Gosharing | 01/11/2020 | Micromobiliteit.nl (2020) | 15/03/2021 |
| Amstelveen | Felyx | 01/12/2019 | Bos (2019) | 02/03/2021 |
| Amstelveen | Check | 01/03/2021 | Gemeente Amstelveen (2021) | 16/03/2021 |
| Nissewaard | Gosharing | 01/09/2020 | Grootnissewaard.nl (2020) | 15/03/2021 |
| Hengelo | Gosharing | 01/09/2020 | Dijkgraaf (2020) | 15/03/2021 |
| Lansingerland | Felyx | 01/08/2020 | Gemeente Lansingerland (2020) | 15/03/2021 |
| Lansingerland | Gosharing | 01/06/2020 | Gemeente Lansingerland (2020) | 15/03/2021 |
| Rijswijk | Gosharing | 01/10/2020 | Rijswijksdagblad (2020) | 05/03/2021 |
| Rijswijk | Felyx | 01/10/2020 | Gemeente Rijswijk (2020) | 05/03/2021 |
| Oosterhout | Gosharing | 01/07/2020 | Bemd (2020) | 17/03/2021 |
| Assen | Gosharing | 01/01/2021 | Emerce (2021) | 15/03/2021 |

| | | | | |
|---|---|---|---|---|
| Vlaardingen | Gosharing | 01/07/2020 | micromobiliteit.nl (2020) | 06/03/2021 |
| Capelle aan den Ijssel | Gosharing | 01/12/2019 | | |
| Schiedam | Felyx | 01/09/2019 | Algemeen dagblad (2019) | 05/03/2021 |
| Schiedam | Gosharing | 01/07/2020 | micromobiliteit.nl (2020) | 06/03/2021 |
| Leidschendam-Voorburg | Gosharing | 01/03/2021 | Deperslijst (2021) | 11/04/2021 |
| Leidschendam-Voorburg | Felyx | 01/03/2021 | Felyx (2021) | 25/03/2021 |
| Barendrecht | Felyx | 01/09/2020 | Gemeente Barendrecht (2020) | 17/03/2021 |
| Barendrecht | Gosharing | 01/09/2020 | Gemeente Barendrecht (2020) | 17/03/2021 |
| Maassluis | Gosharing | 01/07/2020 | 112-middendelfland (2020) | 17/03/2021 |
| Ridderkerk | Gosharing | 01/10/2020 | RTV-Ridderkerk (2020) | 17/03/2021 |
| Geldrop-Mierlo | Gosharing | 01/04/2020 | Berger (2020) | 17/03/2021 |
| Best | Gosharing | 01/09/2020 | Gemeente Best (2020) | 17/03/2021 |
| Son en Breugel | Gosharing | 01/06/2020 | Spooren (2020) | 17/03/2021 |
| Helmond | Gosharing | 01/03/2020 | Clerx (2020) | 15/03/2021 |
| Diemen | Felyx | 01/01/2020 | Diemernieuws (2020) | 15/03/2021 |
| Albrandswaard | Felyx | 01/09/2020 | De Schakel (2020) | 17/03/2021 |
| Albrandswaard | Gosharing | 01/09/2020 | micromobiliteit.nl (2020) | 17/03/2021 |
| Pijnacker-Nootdorp | Felyx | 01/03/2021 | Felyx (2021) | 16/03/2021 |

## Appendix A.4 Bike sharing all market entries

| Municipality | Name of the service | Entry date (year and month) | Reference(s) | Retrieved on |
|---|---|---|---|---|
| Amsterdam | Flickbike | 01/07/2017 | Van Waes et al (2018) | 04/03/2021 |
| Amsterdam | Dropbyke | 01/07/2017 | Dropbyke (2017) | 21/03/2021 |
| Amsterdam | Donkeyrepublic | 01/04/2017 | Donkeyrepublic (2017) | 18/03/2021 |
| Amsterdam | Goabout | 01/11/2020 | Fietsberaad (2020) | 08/04/2021 |
| Rotterdam | Donkeyrepublic | 01/09/2017 | Ramaker (2017) | 18/03/2021 |
| Rotterdam | oFo | 01/11/2017 | Berkelder (2017) | 21/03/2021 |
| Rotterdam | Mobike | 01/11/2017 | Gerlings (2017) | 15/03/2021 |
| Rotterdam | Obike | 01/06/2017 | BusinessInsider (2019) | 21/03/2021 |
| Rotterdam | Lime | 01/10/2019 | Emerce (2019) | 09/03/2021 |
| The Hague | HTM-fiets | 01/05/2019 | HTM (2019) | 19/03/2021 |
| The Hague | Goabout | 01/03/2019 | De Binckhorst Den Haag (2019) | 08/04/2021 |
| The Hague | Donkeyrepublic | 01/10/2020 | Donkeyrepublic (2020) | 18/03/2021 |
| The Hague | Mobike | 01/03/2019 | Mobike (2019) | 18/03/2021 |
| Utrecht | Goabout | 01/04/2017 | Maarten Veenendaal (2017) | 08/04/2021 |
| Utrecht | Donkeyrepublic | 01/04/2019 | Goedopweg (2019) | 15/03/2021 |
| Tilburg | Goabout | 01/03/2018 | Rietveld (2018) | 09/04/2021 |
| Tilburg | Hopperpoint/ bravofiets | 01/10/2020 | Hopperpoint (2020) | 16/03/2021 |
| Eindhoven | Hopperpoint | 01/03/2017 | Mobility-S (n.d.) | 18/03/2021 |
| Groningen | Goabout | 01/04/2018 | GoAbout (2018) | 08/04/2021 |
| Groningen | Slimonderweg | 01/03/2017 | Groningenbereikbaar (2017) | 21/03/2021 |
| Amsterdam | Hellobike | 01/05/2017 | Rijkswaterstaat (n.d.) | 03/05/2021 |
| Rotterdam | Vaimoo | 01/12/2020 | Emerce (2020) | 26/04/2021 |
| Groningen | Deelfiets Nederland | 01/12/2020 | Groningen bereikbaar (2020) | 28/04/2021 |
| Groningen | Bikeshare050 | 01/07/2017 | Dagblad van het noorden (2017) | 26/04/2021 |
| Rotterdam | Gobike | 01/02/2016 | nieuwsfiets (2019) | 03/05/2021 |
| Haarlem | Uwdeelfiets | 01/05/2017 | Uwdeelfiets: Personal respondence | 23/03/2021 |
| Haarlem | Yobike | 01/06/2018 | Sipkes (2018) | 25/02/2021 |
| s'Hertogenbosch | Hopperpoint/ bravofiets | 01/10/2020 | Hopperpoint (2020) | 16/03/2021 |
| Delft | Mobike | 01/06/2018 | Wikipedia (2020) | 02/03/2021 |
| Haarlemmermeer | Uwdeelfiets | 01/05/2016 | Uwdeelfiets: Personal respondence | 23/03/2021 |
| Haarlemmermeer | Flickbike | 01/07/2020 | Schiphol (2021) | 14/04/2021 |
| Haarlemmermeer | Donkey Republic | 01/07/2018 | RickFM (2018) | 22/03/2021 |

| | | | | |
|---|---|---|---|---|
| Zoetermeer | HTM-fiets | 01/05/2020 | Indebuurt (2020) | 19/03/2021 |
| Enschede | Goabout | 01/09/2018 | GoAbout (2018) | 11/04/2021 |
| Nijmegen | Goabout | 01/01/2018 | Platform beter benutten (2018) | 09/04/2021 |
| Zwolle | Goabout | 01/02/2018 | GoAbout (2018) | 11/04/2021 |
| Zaanstad | Flickbike | 01/11/2018 | Zaanstad (2019) | 02/03/2021 |
| Leiden | Common.bike /Easyfiets | 01/03/2017 | Ovmagazine (2017) | 21/03/2021 |
| Apeldoorn | Keobike | 01/12/2016 | keolis (2016) | 04/05/2021 |
| Dordrecht | Nextbike | 01/04/2017 | Nextbike (n.d.) | 04/05/2021 |
| Maastricht | Nextbike | 01/04/2017 | Ovmagazine (2017) | 04/05/2021 |
| Zwolle | Deelfiets Nederland | 01/03/2018 | Hilke Vos (2018) | 04/05/2021 |
| Ede | Keobike | 01/10/2018 | Eric Wijnacker (2018) | 04/05/2021 |
| Leiden | Hello-bike | 01/02/2018 | nu.nl (2018) | 04/05/2021 |
| Amstelveen | Flickbike | 01/07/2017 | Van Waes et al (2018) | 04/03/2021 |
| Bergen op Zoom | Hopperpoint/ bravofiets | 01/10/2020 | Hopperpoint (2020) | 16/03/2021 |
| Helmond | Goabout | 01/04/2020 | Amstel-Smits (2020) | 21/03/2021 |
| Huizen | Uwdeelfiets | 01/09/2017 | De gooi en- Eemlander (2017) | 22/03/2021 |
| Huizen | Donkey republic | 01/01/2018 | Waybackmachine | 22/03/2021 |
| Hillegom | Uwdeelfiets | 01/02/2018 | Uwdeelfiets: Personal respondence | 23/03/2021 |
| Teylingen | Uwdeelfiets | 01/02/2018 | Uwdeelfiets: Personal respondence | 23/03/2021 |
| Middelburg | Goabout | 01/11/2019 | Giele (2019) | 21/03/2021 |
| De bilt | Goabout | 01/03/2018 | Dankbaar (2018) | 21/03/2021 |
| Wageningen | Cykl | 01/07/2017 | Cykl (2017) | 14/04/2021 |
| Vlissingen | Goabout | 01/11/2019 | Giele (2019) | 21/03/2021 |
| Zandvoort | UWdeelfiets | 01/05/2020 | Uwdeelfiets: Personal respondence | 23/03/2021 |
| Velsen | Uwdeelfiets | 01/02/2018 | Uwdeelfiets: Personal respondence | 23/03/2021 |
| Beverwijk | Uwdeelfiets | 01/02/2018 | Uwdeelfiets: Personal respondence | 23/03/2021 |
| Den Helder | Uwdeelfiets | 01/06/2020 | Uwdeelfiets (2020) | 29/04/2021 |
| Aalsmeer | Flickbike | 01/05/2018 | Het Parool (2018) | 23/03/2021 |
| Schiedam | Donkey republic | 01/10/2019 | Schiedamsnieuws (2020) | 11/04/2021 |
| Leusden | Keobike | 01/12/2016 | Keolis (2016) | 04/05/2021 |
| Barneveld | Keobike | 01/03/2018 | Ovpro (2018) | 04/05/2021 |
| Kampen | Deelfiets Nederland | 01/06/2020 | Van der Wal (2020) | 04/05/2021 |
| Capelle aan de ijssel | Vaimoo | 01/12/2020 | Emerce (2020) | 26/04/2021 |

## APPENDIX B. CORRELATION MATRIX

**Correlation Matrix**

| | Population.density | Population.size | Public.transport | Household.size | Surface.area | Demographic.pressure | Income | Cyclist.friendliness | Car.ownership | Car | Scooter | Bike |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population.density | 1 | | | | | | | | | | | |
| Population.size | 0.490 | 1 | | | | | | | | | | |
| Public.transport | -0.190 | -0.15 | 1 | | | | | | | | | |
| Household.size | -0.350 | -0.39 | 0.28 | 1 | | | | | | | | |
| Surface.area | -0.190 | 0.36 | -0.01 | -0.08 | 1 | | | | | | | |
| Demographic.pressure | -0.400 | -0.56 | 0.07 | 0.41 | -0.16 | 1 | | | | | | |
| Income | -0.110 | -0.21 | 0.03 | 0.35 | -0.27 | 0.43 | 1 | | | | | |
| Cyclist.friendliness | 0.860 | 0.29 | -0.23 | -0.35 | -0.39 | -0.32 | -0.1 | 1 | | | | |
| Car.ownership | -0.670 | -0.6 | 0.29 | 0.66 | -0.14 | 0.6 | 0.26 | -0.49 | 1 | | | |
| Car | 0.210 | 0.56 | -0.14 | -0.27 | 0.19 | -0.39 | -0.1 | 0.18 | -0.38 | 1 | | |
| Scooter | 0.390 | 0.43 | -0.08 | -0.25 | 0.08 | -0.37 | -0.09 | 0.38 | -0.41 | 0.39 | 1 | |
| Bike | 0.390 | 0.47 | -0.2 | -0.38 | 0.18 | -0.43 | -0.14 | 0.24 | -0.53 | 0.32 | 0.29 | 1 |

# APPENDIX C. R CODE

## APPENDIX C.1 DESCRIPTIVE STATISTICS

```
#Descriptive statistics
library(stargazer)
data <- read.csv('Linear.csv', header = TRUE, sep = ";")
colnames(data)[15] <- 'Car'
colnames(data)[16] <- 'Scooter'
colnames(data)[17] <- 'Bike'
Descriptive_variables <- subset(data, select = -c(1,9, 12,13,14))
stargazer(Descriptive_variables, type = "text", out= "descriptive_statistics.html",
          omit.summary.stat = c("p25", "p75"), digits = 2)

#Correlation
library(devtools)
library(Hmisc)
cor.data <- data[, -c(1,9,12,13,14)]
m <- rcorr(as.matrix(cor.data), type="pearson")
n<-data.frame(m$r)
upper <- round(n,2)
upper[upper.tri(upper)]<-""
upper<-as.data.frame(upper)
upper
stargazer(upper, title="Correlation Matrix", type = "text", out =
            "correlationmatrix.html", summary = FALSE)

#Descriptive figure
library(ggplot2)
library(tidyverse)
data <- read.csv('Descriptive.csv', header = TRUE, sep = ";")

#Plot of initial introductions
DATE  <- as.Date(as.character(data$Date),"%d/%m/%Y")
DATE2 <- as.Date(as.character(data$Date.1),"%d/%m/%Y")
DATE3 <- as.Date(as.character(data$Date.2),"%d/%m/%Y")

plot(x= DATE, y= data$BM.number.bike, type = "b", xlab = "Time",
     ylab = "First BM introductions", xlim=as.Date(c("2011-01-01", "2021-03-01")),
     ylim = c(0, 41), col = "green", cex = 0.5)
lines(x=DATE2, y= data$BM.number.car, col = "red", type = "b", cex = 0.5)
lines(x=DATE3, y=data$BM.numer.scooter, col= "blue", type ="b", cex = 0.5)
legend(x=as.Date("2011-01-01"), y=40, legend = c("CAR", "Scooter", "Bike"),
       fill = c("red", "blue", "green"))
```

## APPENDIX C.2 REGRESSION CODE CARSHARING

```
#Load Data and packages
library(survival)
library(Hmisc)
library(dplyr)
library(stargazer)

data <- read.csv('Car_surv.csv', header = TRUE, sep = ";")
data <- mutate(data, Population.size = as.integer(data$Population.size/10000))
data <- mutate(data, Population.density = as.integer(data$Population.density/100))

#Cox regressions
Demographics <- coxph(Surv(tstart, tstop, event) ~
Demographic.pressure + Population.size + Household.size +
Population.density, data = data, id=id)
summary(Demographics)

Null.model <- coxph(Surv(tstart, tstop, event) ~  Income +
Car.ownership + Income + Public.transport + Surface.area, data = data, id=id)
summary(Null.model)

Scooter <- coxph(Surv(tstart, tstop, event) ~ Scooter + Income +
                   Car.ownership + Income + Public.transport + Surface.area
                , data = data, id=id)
summary(Scooter)

Bike <- coxph(Surv(tstart, tstop, event) ~ Bike  + Income +
                   Car.ownership + Income + Public.transport + Surface.area
                 , data = data, id=id)
summary(Bike)

Scooter.and.bike <- coxph(Surv(tstart, tstop, event) ~ Bike + Scooter + Income +
                   Car.ownership + Income + Public.transport + Surface.area
                 , data = data, id=id)

Combined <- coxph(Surv(tstart, tstop, event) ~ Scooter + Bike + Car.ownership + Income +
Demographic.pressure + Surface.area + Public.transport + Population.size + Household.size
+ Population.density, data = data, id=id)
summary(Combined)

#likelihood ratio test (for model improvement)
a <- (-2)*(Null.model$loglik - Demographics$loglik)[2]
a <- round(a, 2)
b <- (-2)*(Null.model$loglik - Scooter$loglik)[2]
b <- round(b, 2)
c <- (-2)*(Null.model$loglik - Bike$loglik)[2]
c <- round(c, 2)
d <- (-2)*(Null.model$loglik - Scooter.and.bike$loglik)[2]
d <- round(d, 2)
e <- (-2)*(Null.model$loglik - Combined$loglik)[2]
e <- round(e, 2)

#Coefficient table
stargazer(Demographics, Null.model, Scooter, Bike, Scooter.and.bike, Combined,
```

```
type = "text", out="Car_analysis.html", dep.var.caption = "", apply.coef = exp,
t.auto=F, p.auto=F, font.size = "huge", model.numbers=FALSE, header = FALSE,
dep.var.labels.include = FALSE, column.labels = c("Demographics", "Null.model",
"Scooter", "Bike", "Scooter.and.bike", "Combined"), omit.stat = c("ll", "lr", "rsq",
"max.rsq", "wald", "logrank"), add.lines = list(c("Number of events", "17", "17", "17",
"17", "17", "17"), c("LLR-test", a, "", b, c, d, e),
c("compared to", "null model", "", "null model", "null model","null model", "null model")),
table.layout = "#c-t-sa-n",star.cutoffs = c(.05, .01, .001))
```

## Appendix C.3 Regression code scooter sharing

```
#Load Data and packages
library(survival)
library(Hmisc)
library(dplyr)
library(stargazer)
require(survival)

data <- read.csv('Scooter_surv.csv', header = TRUE, sep = ";")
data <- mutate(data, Population.size = as.integer(data$Population.size/10000))
data <- mutate(data, Population.density = as.integer(data$Population.density/100))

#Cox regressions urbanity
Demographics <- coxph(Surv(tstart, tstop, event) ~
Demographic.pressure + Population.size + Household.size +
Population.density, data = data, id=id)
summary(Demographics)

Null.model <- coxph(Surv(tstart, tstop, event) ~  Income +
Cyclist.friendliness + Income + Public.transport + Surface.area, data = data, id=id)
summary(Null.model)

Car <- coxph(Surv(tstart, tstop, event) ~ Car + Income + Cyclist.friendliness +
                    Income + Public.transport + Surface.area
                   , data = data, id=id)
summary(Car)

Bike <- coxph(Surv(tstart, tstop, event) ~ Bike  + Income +Cyclist.friendliness+
             Income + Public.transport + Surface.area
             , data = data, id=id)
summary(Bike)

Car.and.bike <- coxph(Surv(tstart, tstop, event) ~ Bike + Car + Income +
                Cyclist.friendliness+ Income + Public.transport + Surface.area
                    , data = data, id=id)
summary(Car.and.bike)

Combined <- coxph(Surv(tstart, tstop, event) ~ Car + Bike +  Income +
Demographic.pressure + Surface.area + Public.transport + Population.size
+ Population.density + Household.size, data = data, id=id)
summary(Combined)

#likelihood ratio test (for model improvement)
a <- (-2)*(Null.model$loglik - Demographics$loglik)[2]
a <- round(a, 2)
b <- (-2)*(Null.model$loglik - Car$loglik)[2]
b <- round(b, 2)
c <- (-2)*(Null.model$loglik - Bike$loglik)[2]
c <- round(c, 2)
d <- (-2)*(Null.model$loglik - Car.and.bike$loglik)[2]
d <- round(d, 2)
e <- (-2)*(Null.model$loglik - Combined$loglik)[2]
e <- round(e, 2)

#Imiation
stargazer(Demographics, Null.model, Car, Bike, Car.and.bike, Combined, type = "text",
          out="Scooter_analysis.html", dep.var.caption = "", apply.coef = exp,t.auto=F,
          p.auto=F, font.size = "huge", model.numbers=FALSE, header = FALSE,
          dep.var.labels.include = FALSE,
          column.labels = c("Demographics", "Null.model", "Car", "Bike", "Car.and.bike",
          "Combined"),
          omit.stat = c("ll", "lr", "rsq", "max.rsq", "wald", "logrank"),
          add.lines = list(c("Number of events", "17", "17", "17", "17", "17", "17"),
         c("LLR-test", a, "", b, c, d, e),
          c("compared to", "null model", "", "null model",
          "null model","null model", "null model")),
          table.layout = "#c-t-sa-n",star.cutoffs = c(.05, .01, .001))
```

## Appendix C.4 Regression code bike sharing

```
#Load Data and packages
library(survival)
library(Hmisc)
library(stargazer)
library(dplyr)
require(survival)

data <- read.csv('Bike_surv.csv', header = TRUE, sep = ";")
data <- mutate(data, Population.size = as.integer(data$Population.size/10000))
data <- mutate(data, Population.density = as.integer(data$Population.density/100))
colnames(data)[8]<- 'Car.and.scooter'
colnames(data)[9]<- 'Presence.any'
colnames(data)[10] <- 'Car.ownership'
colnames(data)[18]<- 'Cyclist.friendliness'


#Cox regressions
Demographics <- coxph(Surv(tstart, tstop, event) ~
                    Demographic.pressure + Population.size + Household.size +
                    Population.density, data = data, id=id)
summary(Demographics)

Null.model <- coxph(Surv(tstart, tstop, event) ~  Income +Cyclist.friendliness+
                   Income + Public.transport + Surface.area,
                    data = data, id=id)
summary(Null.model)

Scooter <- coxph(Surv(tstart, tstop, event) ~ Scooter + Income +Cyclist.friendliness+
                    Income + Public.transport + Surface.area
                  , data = data, id=id)
summary(Scooter)

Car <- coxph(Surv(tstart, tstop, event) ~ Car  + Income +Cyclist.friendliness+
               Income + Public.transport + Surface.area
              , data = data, id=id)
summary(Car)
```

```r
Car.and.scooter <- coxph(Surv(tstart, tstop, event) ~ Car + Scooter + Income
                         +Cyclist.friendliness+
                             Income + Public.transport + Surface.area
                          , data = data, id=id)
summary(Car.and.scooter)

Combined <- coxph(Surv(tstart, tstop, event) ~ Scooter + Car + Income +
                    Demographic.pressure + Surface.area + Public.transport +
                    Population.size + Household.size +
                    Population.density, data = data, id=id)
summary(Combined)

#likelihood ratio test (for model improvement)
a <- (-2)*(Null.model$loglik - Demographics$loglik)[2]
a <- round(a, 2)
```

```r
b <- (-2)*(Null.model$loglik - Car$loglik)[2]
b <- round(b, 2)
c <- (-2)*(Null.model$loglik - Scooter$loglik)[2]
c <- round(c, 2)
d <- (-2)*(Null.model$loglik - Car.and.scooter$loglik)[2]
d <- round(d, 2)
e <- (-2)*(Null.model$loglik - Combined$loglik)[2]
e <- round(e, 2)

#Imiation
stargazer(Demographics, Null.model, Scooter, Car, Car.and.scooter,
          Combined, type = "text",
          out="Bike_analysis.html", dep.var.caption = "",
          apply.coef = exp,t.auto=F, p.auto=F,
          font.size = "huge", model.numbers=FALSE, header = FALSE,
          dep.var.labels.include = FALSE,
          column.labels = c("Demographics", "Null.model", "Scooter", "Car",
                            "Car.and.scooter", "Combined"),
          omit.stat = c("ll", "lr", "rsq", "max.rsq", "wald", "logrank"),
          add.lines = list(c("Number of events", "17", "17", "17", "17", "17", "17"),
                           c("LLR-test", a, "", b, c, d, e),
                           c("compared to", "Null model", "", "null model",
                             "null model","null model", "null model")),
          table.layout = "#c-t-sa-n",star.cutoffs = c(.05, .01, .001))
```