Governance of Dockless Bicycle Sharing

An exploration of governance mechanisms for coping with the disruptive phenomenon of dockless bicycle sharing systems by identifying public values

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Preface

Before you lies the thesis "Dockless Bicycle Sharing: Innovation in Urban Mobility", which is a result of work towards the achievement of an MSc in Systems Engineering, Policy Analysis, and Management. This research is performed during an internship at Advier in Delft. I started my master in 2015 and studied for several months in the city of Harbin, China. Here I learned about the culture, politics, and business in the Chinese context. This was also the moment I first encountered dockless bicycle sharing. The innovative features and the fact that I did not see these systems before in the Netherlands intrigued me. This was the moment the initial idea of this thesis emerged.

I could never expect that this innovation would launch in the Netherlands during my research and that it gave momentum and urgency to dive into this matter. The actuality of the innovation resulted in attending a lot of interesting meetings and debates on the subject.

This thesis is predominantly written for authorities challenged with the governance of dockless bicycle sharing systems. My gratitude goes to all municipal experts for providing me with useful information about the potential adoption of BSS, this was of crucial importance for my research.

Secondly, I would like to thank my intern company Advier for giving me the opportunity to work on my thesis and providing an interesting view of how a cooperative company is formed. With special thanks to Minze Walvius.

Secondly, my graduation committee for guiding me in the right direction. The feedback was useful and welcome to get to the core of my research, one can get lost during his research.

Finally, my deep gratitude goes to my family and friends. Piet, Lous, Stijn, Ivar, Jakar and Lars for never stopped believing in me.

For now, I would like to wish you a pleasant reading.

Yorik Janmaat
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Abstract

This research provides insight into coping with the appearance of dockless bicycle sharing systems (BSS) in a municipal context. Due to technological developments like GPS integration and smart locks, BSS evolved towards the latest development of dockless shared bicycles. Most BSS companies were from Asian origin and had a disruptive impact on cities like Amsterdam and Rotterdam in the summer of 2017. The introduction of multiple bicycle sharing systems caused nuisance and raised questions about the added value for society of this new innovation in urban mobility.

The goal of the study is exploring applicable and tangible governance options for municipalities to cooperate with or regulate operators and implement a BSS in their municipality. Important in this respect is the fit with the values of society to establish city objectives, but also to take into account the functionality of a dockless BSS.

Dutch municipalities struggle to cope with BSS. They lack knowledge about the factors of influence in the systems. This is needed for considering regulation or acceptance of BSS by the public in general. Dockless BSS has proven to behave highly disruptive and this causes friction between public values and private interests. Therefore cities need means to evaluate and cope with BSS initiatives. Research concerning BSS and public values in a high-cyclists country context is also lacking, therefore the Netherlands as the geographical scope is an interesting addition to prior literature. Therefore the question that is raised in this research is:

> *How can Dutch municipalities cope with the disruptive innovation of dockless bicycle sharing in order to resolve the conflicts between public and private values?*

The research method used consists of an extensive literature review. Which provided a theoretical foundation on the themes of sharing platforms, mobility and governance in relation to dockless bicycle sharing. It was found that present sharing schemes have a product-service economy appearance because no peer-to-peer element exists. The free-floating schemes provide more flexibility to the users towards the origin and destination of their trips in comparison to docking systems. In relation to governance, authorities have three main ways to govern: prohibit/enforce, pricing and soft regulation. These are used to develop coping measures in the design phase of governance strategies. Together with findings from subject-related meetings, the initial system overview is constructed, which clarified the causal relations between the pressure on public space in relation to the number of bicycles, utilization rates and a number of operators.

These insights resulted in a list of topics to discuss with municipal experts in the field of BSS. Nine experts of municipalities throughout the Netherlands were interviewed. Data of a dockless operator and the private values of operators substantiated the findings of the interviews.

Results of trip data indicated that the dockless system was for 85% used by inhabitants and that use during the day was highly similar to foreign BSS usage. From the interviews with municipalities, important public values were identified. Public values are the needs and wishes for the short and long term, pursued by authorities and can be abstract and operational.

The conflicts between these public values and the private values are the problems of the municipality to cope with.

Four dominant conflicts between public values and private values were identified:
Public space (quality, control & no commercialization). The public space (quality, control and no commercialization) is highly valued. Municipalities struggle to control the quality of public space without commercialization of this public space. The impact of BSS on this public domain can conflict quality requirements and enforcement of wrongly parked bicycles. Since operators try to maximize their freedom to use public space, this can provide conflicts.

Additional *costs for municipalities* not be covered by inhabitants if a commercial company uses the public domain as their point of issue for their shared bicycles. If extra costs are made for parking spots or enforcement, it is considered unfair that the municipality covers these costs. Operators currently do not contribute to municipal expenses for enforcement of the wrongly parked bicycles.

If a BSS is allowed in a municipality the public desires high *quality of bicycles*. Since there is limited space for the number of bicycles and operators, the present BSS needs to fulfil the quality requirements of potential users. The first systems introduced in the Dutch cities did not meet the standards of Dutch bicycles and the quality was therefore not sufficient in the eyes of potential users.

The bicycle sharing schemes should add value in addition to the current mobility options. It should provide *flexibility* for the user, but also be useful in relation to *public transport*. The introduction of BSS is not automatically introduced in relation to public transport. In addition, train stations are often limited in parking space or forbidden for bicycles, therefore operators cannot use this space as a point of issue. The conflict exists in the balance between flexibility for the operator to provide a positive business-case and create a good service for users and become a desired addition to the current mobility options by authorities.

The private values identified from an interview with a BSS operator and public hearings were: *make a profit, limit company costs, maximize the number of users, maximize the number of bicycles, maximize freedom to use public space, limited openness to competitors and municipality, commercialization of public space and collection of user data.* These values do provide conflicts with public values, therefore coping measures should be introduced to regulate the BSS market.

Based on these conflicts sets of coping measures are designed per public value.

Public space (Quality, control & no commercialization): Determine minimal usage of a bicycle per day, Restrain commercialization of public space through legislation, Require accelerometers in the bicycles to identify fallen bicycles, Introduce a Universal logo for bicycle sharing, Require good behaviour incentives, Enforce geofences, Create incentives to have bicycles moving, Require a communication channel for all complaints, Ensure even spread of the bicycles and Require openness in trip data.

Costs for the municipality: Arrange parking facilities for the period the number of bicycles in the city is higher, these costs for extra facilities can be calculated in permit fees or with other forms

of contracts. In addition, make handling wrongly parked bicycles at least break even. This means that costs for removing wrongly parked bicycles should be paid by the operators.

Quality of the bicycles: Establish quality standards and assessments before introduction, Ensure sustainability of the produced bicycles and monitor the quality performance during use.

Mobility (Public transport addition & flexibility): Allocate space for BSS near mobility hubs, for instance near public transport locations. Force integration of BSS with PT offer by making it part of a concession.

This results in some recommendations: all issues of concern with respect to dockless BSS must be taken into account. Public values provide a good starting point to explore municipal needs. These objectives for the particular municipality can be defined upfront, so before operators are introduced. To guarantee integration with other modes of transport, postulate conditions for the addition to the present mobility system. To limit municipal costs, transaction costs for individual municipalities can be reduced by execution of certifications or share knowledge about operators and the systems at the national level. In addition, concrete enforcement should be explored. The actual implementation is subject to local context, the measures provided are therefore not one size fits all, but can be used as a set of options for municipalities.

The analysis of public values in contrast to private values in order to find conflicts regarding the introduction of BSS proofed to be valuable for research like this. It can provide insights into the contribution to the mobility system in cities and possibly contribute to an alternative that can be offered to currently available personal mobility.

The findings of this research are generalizable in the Dutch context. Dutch municipalities of various sizes and regions were interviewed for this study. During interviews, a lot of similar issues were presented by the interviewees, which lead to the saturation of answers. Besides, foreign cities can benefit from the insights if similar public values conflict with private values.

Constraints in time and resources limit the number of municipalities that could be taken into account for this research. The researcher was also dependent on experts that are willing to talk about the subject. Further research should conduct on gaining better insight in usability patterns of users, this requires openness of data by the operators.

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Table 1: Abbreviations

Abbreviation	Definition
BSS	Bicycle sharing system
B2O	Back-to-one
B2M	Back-to-many
FF	Free-floating
GF	Geofence
App	Application
PT	Public Transport
OAD	Address density
SLA	Service level agreement
MOU	Memorandum of understanding
KPI	Key performance indicator
APV	General local regulation
MaaS	Mobility-as-a-Service
HOV	High-quality public transport

Glossary

Table 2: Glossary

Concept	Definition
Public value	Public values are the needs and wishes of inhabitants for the short and long run, pursued by authorities and can be abstract and operational
Bicycle sharing system (BSS), Bike-share scheme (BSS), Public bicycle system (PBS), Bike-sharing program (BSP)	The socio-technical system in which *shared bicycles* are offered
Shared bicycle (Public bicycle)	Bicycles that are offered at limited costs for a short period of time in a network on public space and are accessible 24/7 to potential users
Bicycle sharing station	Assigned bicycle station where a *shared bicycle* can be picked up or returned
Bicycle sharing location	Location in a public space where a *shared bicycle* can be picked up or returned
Bicycle sharing network	Distribution of *Bicycle sharing stations* in a city
Docking station	A form of an unmanned *bicycle sharing station;* where the *shared bicycle* is parked
Free-floating bicycles	Bicycles that are not attached to a *docking station* and allowed to move freely through the city, usually app controlled
Dockless bicycle sharing	A *BSS* that is operating with *free-floating bicycles* or *geofence technology* and is app-controlled
Station based bicycle sharing	A BSS that is operated using *bicycle sharing stations* at which the *shared bicycles* have to be returned
Back-to-one bicycle sharing	The system in which the *shared bicycle* should be returned at the initial location
Back-to-many bicycle sharing	The system in which the *shared bicycle* can be returned to more locations, not necessarily the initial location
Geofence	Allowed operating area that is virtually demarcated using GPS
Interoperability	Possibility for different autonomous BSS operators to work together. For shared bicycles, this means that different systems can be used with one general application by users
The last-mile problem	The problem of getting people from a *transport hub* to their final destination. The *first-mile problem* also exists.
Mobility chain	The general term of combining modes of transport for a trip from A to B. This combination is called a 'chain'
Active modes	A collective name for cycling and walking
Transport hub	A place where people change from one mode of transport to another

In this thesis the following definition of shared bicycles is used:

"Shared bicycles are bicycles that are offered at limited costs for a short period of time in a network in public space and are accessible 24/7 to potential users"

1 Introduction

1.1 Background

1.1.1 History of Bicycle Sharing

Bicycle sharing systems (BSS) have evolved drastically since the first scheme in 1965. The Netherlands is the country where it once started with the 'white bicycle plan' in the city of Amsterdam (Davis, 2014). These bicycles were free of charge and unlocked. This turned out not to be a great success: within several months many were painted another colour, stolen or vandalized. The second generation bicycle sharing systems started in Copenhagen in 1995 with a coin-deposit system, people could unlock the bicycles with a Danish coin (Shaheen, Guzman, & Zhang, 2010). The third generation systems from around 2007 integrated more advanced technology like pick-up and drop-off stations, tracking information for the operators and kiosks or interface technology was used (Shaheen et al., 2010). A lot of these systems were initially started by local governments but later on operated by non-profit organizations or advertisement companies, like the Vélib scheme in Paris, operated by JC Decaux in return for advertising spaces in the inner city (Bullock, Brereton, & Bailey, 2016)). The fourth generation from 2009 onwards is characterized as demand-responsive, incorporates in a multimodal system and the bicycle distribution is optimized (Shaheen et al., 2010). Since then the number rapidly increased to more than 1000 schemes currently (DeMaio & Meddin, 2017). Roland Berger estimated the total shared bicycle market to be around 5.3 billion euros by 2020 (Roland Berger, 2014).

1.1.2 The Dutch context

Despite the fact that the first bicycle sharing program was started in The Netherlands in 1965, the white bicycle plan, the blossom of bicycle sharing globally passed the Dutch municipalities for a long time. Nevertheless, over the last years also Dutch bicycle sharing initiatives were started or explored (Tour de Force, 2017). Next to that, a completely different cycling culture is present in the Netherlands. The Dutch have many personal bicycles in contrast to other bicycle sharing countries, 1,3 bicycle per inhabitant on average (KiM, 2015), compared to the European average of 0,4 bicycles (Fietsplatform, 2013). It is argued that the high ownership of private bicycles can have an effect on the adoption of a bicycle sharing scheme (Gemeente Amsterdam, 2017). This might influence the potential of a successful bicycle sharing in the Netherlands. On the other hand, the infrastructure for cyclists is of much higher quality and more widespread than in Belgium or the United States (Pucher, Dill, & Handy, 2010). This means that safety for cyclists is also much higher than in countries with a lesser developed cycling culture where shared bicycles are implemented (E. Fishman & Schepers, 2016).

Because of the well-developed cycling infrastructure, it might become a part of the mobility market in the Netherlands much faster if it is a well-functioning system that many people see as added value (Médard, Chardon, Caruso, & Thomas, 2017). This added value can be interpreted as a *public value*, that is defined by (Moore, 1995) as increasing value to the public domain in the short and the long run.

Dockless BSS have however proven to behave highly disruptive, for instance, because of the presence in public space. Over the last year, hundreds of news articles were written about the flood of free-floating bicycles and the impact it has on cities in terms of thrown-away and abandoned bicycles (Trouw, 2017). A lot of unrest among the inhabitants was caused when several free-floating operators entered the city of Amsterdam (NRC, 2017). The disruptive behaviour of the dockless bicycles forced the municipality of Amsterdam to take action. As a result, the authorities ordered to remove all the shared bicycles out of the city and decided to regulate the bicycle sharing scheme in the future, which resulted in a shared bicycle permit concept (Gemeente Amsterdam, 2017).

In order to develop a general understanding on the municipal objectives, using an objective tree concerning sustainable mobility and the effects on a city, four main objectives are identified as shown in Appendix A. These objectives are; Less use of space by modes of transport, more sustainable mobility, better liveability and better accessibility. These objectives are further operationalized in the objective tree and formed the basis for the research objective. This overview of objectives also clarifies the drivers for municipalities in general when they develop mobility policies.

Considering all possible benefits, but also all possible negative effects, Dutch municipalities struggle to cope with dockless BSS in Dutch cities. They lack knowledge about the factors of influence on considering functioning, acceptance, and regulation of BSS operators.

1.1.3 Prior studies

Several studies worldwide have tried to understand the relationship between bicycle share users and regular cyclists to predict the possible effects of wide implementation within a city on personal bicycle ownership, congestion, and healthy lifestyles. These studies were directed at various topics surrounding bicycle sharing and were all conducted outside of the Netherlands. They cover mostly technical and business-related topics. P.J. DeMaio (2003) was the first to identify the so-called generations of bicycle sharing as introduced before, he also specified success factors for BSS in the US like customer demand, user safety, theft and vandalism and multimodal connectivity (Demaio & Gifford, 2004). Elliot Fishman, Washington, & Haworth (2012) studied the barriers and facilitators, they focussed on themes like weather & topography, spontaneity & accessibility for users and safety. They identified an issue with helmet laws, recommended to communicate mobility benefits and advised to connect BSS with public transport nodes. Several studies, like Pfrommer, Warrington, Schildbach, & Morari (2014) and Reiss & Bogenberger (2015) addressed the issue of rebalancing the bicycles in an appropriate way and also provided solutions like forecasting methods and including user incentives to relocate the bicycles in a better way. E. Fishman (2016) provided several overviews of the rise of BSS all over the world and also identified user preferences and evaluated the impact of implementation. More prior literature themes can be found in Appendix B, which shows that general overviews, success determinants, rebalancing issues and safety were frequent themes in prior studies.

In the described studies not much effort has been put in exploring the public values concerning BSS yet. Of the studies that were found only 2 of 36 were specifically directed at exploring the

impact on public values: safety and health effects. As a result, no governance experience is documented in this domain. This is marked as a gap that deserves more attention because of the many examples of municipalities and people struggling with the introduction in their living environment.

Dutch cycling culture is quite unique in the world. The amount of bicycles is significantly higher in Dutch cities than where most current BSS literature is based on. Therefore most conclusions and case studies really have to be interpreted carefully before applying the findings in a Dutch context. Researching bicycle sharing in relation to a country with high bicycle ownership is, therefore, a gap in the current scientific literature.

1.2 Objective and research questions

Considering the fact that Dutch municipalities struggle with the implementation of BSS and the fact that prior studies did not focus on public values and the Dutch situation, the question that is faced in this thesis is:

How can Dutch municipalities cope with the disruptive innovation of dockless bicycle sharing in order to resolve the conflicts between public and private values?

This main question is divided into three sub-questions:

1. *What are the characteristics and developments of dockless bicycle sharing systems?*
2. *What conflicts between private and public values occur when implementing a dockless bicycle sharing system in Dutch municipalities?*
3. *What measures can Dutch municipalities take to cope with these conflicts?*

The goal of the study is exploring applicable and tangible governance options for municipalities to cooperate with or regulate operators and implement a BSS in their municipality. Important in this respect is the fit with the values of society, establish city objectives and take the functionality of a dockless BSS into account.

1.3 Scope

Since most prior BSS literature, which is discussed in paragraph 2.1, is based on foreign cases, the scope of the research will be Dutch municipalities. Although the literature of foreign studies can be used as a reference for analysis in the Dutch municipalities.

Besides the national bicycle culture, there are also differences between cities in bicycle use in the Netherlands. The level of urbanity, cycling tradition, and bicycle infrastructure are of influence for bicycle use (KiM, 2015). It is presumed that there will also be differences between cities in the Netherlands in relation to BSS, therefore municipalities spread across the Netherlands and of different sizes and urbanity will be taken into account.

In the Netherlands levels of urbanity (OAD) are defined in 5 levels:

1 very urban: an average of 2500 or more house addresses per km2
2 strong urban: average from 1500 to 2500 house addresses per km2
3 moderately urban: average from 1000 to 1500 house addresses per km2

4 little urban: an average of 500 to 1000 house addresses per km2
5 not urban: an average of fewer than 500 house addresses per km2

For this research, only municipalities with level 1,2 and 3 are taken into account. Also because operators show to prefer larger cities to start their operations.

Furthermore, this research will only elaborate on dockless BSS, which will be defined in chapter 3.

1.4 Contribution

The contribution of this thesis is two-sided. On the one hand there is the scientific relevance and on the other hand the societal relevance. Both are concisely discussed below.

1.4.1 Scientific relevance

As stated in paragraph 1.1.3 not much research has been executed on the public values in the context of bicycle sharing. Therefore, identifying public values and designing governance strategies in the domain of BSS contribute to the field of knowledge of public-private cooperation. The scope that has been chosen (Dutch context) is where the gap of knowledge exists. Since there are not many countries with high bicycle ownership studied in the context of BSS, this research can contribute to further research on BSS in relation to high bicycle ownership in a country.

1.4.2 Societal relevance

Contribution to better public-private cooperation in dockless BSS projects. Eventually, contributing to a higher success rate in implementation, by taking public values into account. Designing for public values is ultimately beneficial for society. Furthermore, the study gives better insight into potential governance of cycling innovations in Dutch municipalities.

Urban mobility in the form of bicycle sharing is becoming a key mode of transport in cities worldwide. So understanding the dynamics at play in such a system is gaining importance.

1.5 Reading guide

As shown in figure 1, this report consists of six chapters. This first chapter introduced the situation and complication. Chapter 2 elaborates on the methods that are used to answer the research questions. Chapter 3 proposes the literature used in the research. Chapter 4 includes the results of the research methods brought into practice. Based on the results, chapter 5 will elaborate on the design of the measures for governance. Chapter 6 will conclude and discuss the findings of the research.

Figure 1: Research flow and corresponding chapters

2 Methods

In chapter 1 the situation and complication of the research are discussed. Also, the main research question is introduced. In this chapter, the method is explained that will lead to answering the main question. In paragraph 2.1 a figure is shown that includes the method framework and what sub question each part will answer. In the following paragraphs, every method will be further elaborated on and explained in detail how it is executed.

2.1 Approach (structure)

To answer the main research question multiple methods will be used. Figure 2 shows how these methods relate and contribute to each other. The blue boxes represent the methods and the arrows represent the output and input for the associated methods. The dotted boxes represent the part of the research approach that answers a subquestion.

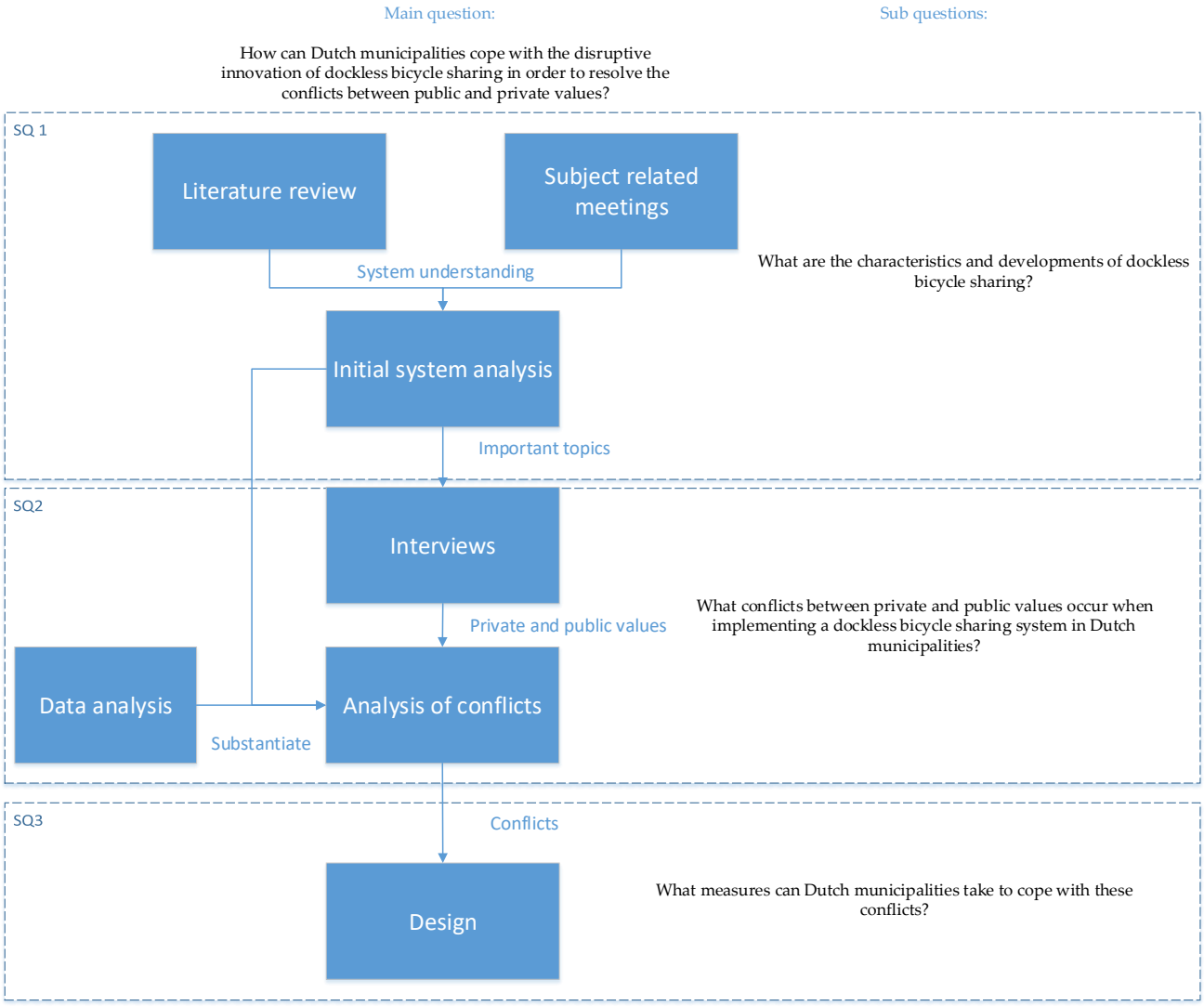

Figure 2: The research approach

2.2 Literature

This study consisted of different rounds of desk research. The initial desk research consisted of the search for literature about sharing platforms and sharing economy in general. The search for literature focussed on the three pillars: sharing platforms, mobility and governance. This was elaborated with scientific articles about free-floating BSS, smart mobility and theories on public values. The search engines that were used were dominantly Scopus and Google Scholar. Semi and non-academic sources were also found by using the general search engine Google. During the search for interesting sources keywords like: "Sharing economy", "Bicycle sharing", "BSS", "Smart Mobility", "free-floating" and "public values" were used. Public value publications were also gathered by the reference list of courses of the study Systems Engineering, Policy Analysis and Management, where this field of the theory was used and discussed.

The literature that was useful and used during the research was mostly downloaded in PDF format and the correct information about the source was adjoined. The software Mendeley Desktop was used to index all the sources and sort the different sources based on the subject. This made it easy to find the sources based on subject and the software made it possible to include sources into the main report.

2.3 Subject related meetings

To gain a good understanding of the matter, several bicycle sharing meetings were attended. These were found via the platform CROW, a non-for-profit knowledge institute for mobility and infrastructure challenges (Fietsberaad CROW, 2017a). These meetings were attended by a lot of experts and involved people in the field of interest, namely the introduction of bicycle sharing in the Netherlands. These attendees were both from the public sector; civil servants on a local and national level, and private sector; bicycle sharing operators. Besides these stakeholders also consultants and public transport operators were present. So a lot of information and viewpoints were gathered based on the discussions and input during these events. The insights from these meetings gave input for the initial system overview, which will be introduced in paragraph 2.4.

Three meetings concerning BSS in the Netherlands were attended.

September 19th, 2017 – Pakhuis de Zwijger – 'Het deelfietsdilemma'

The theme of the meeting: 'Sharing is not always caring. The BSS vs the public space. Time for a conversation about the bicycle sharing dilemma (Pakhuis de Zwijger, 2017).'

November 2nd, 2017 – CROW – 'Verder met de deelfiets'

The theme of the meeting: 'Interoperability, how do we ensure that the user of BSS in the future can use shared bicycles of different operators with one account? (Fietsberaad CROW, 2017b)'

The theme: 'The BSS get a second chance from the municipality. How do we ensure that it becomes a success for everyone? (Pakhuis de Zwijger, 2018)'

2.4 Initial system analysis

The initial system analysis is made based on the insight gathered from the literature study (2.2) and the subject related meetings (2.3). This initial system analysis was made in the form of a causal loop diagram. This diagram with causal relations focussed on important relations between aspects in the field of free-floating bicycle sharing and their positive or negative relation (Sterman, 2000). These relations are important to use and understand during the interviews with municipalities and during the design phase of measures.

Together with the literature study and the case related meetings this initial system analysis will answer subquestion 1, as presented in figure 2. The outcomes of the model can be used to test the found conflicts later in the process and the development of useful measures for the most dominant conflicts.

2.5 Interviews

During a meeting of the CROW, only open to municipal stakeholders, I was able to see what cities were present at this event. This gave me the opportunity to see what cities were struggling and gathering information about the BSS circumstances. Some prior understanding of the matter BSS was seen as important so an in-depth interview could be executed with the concerning municipalities. The names and contact information of multiple attendees were collected and contacted. The municipalities contacted were of different sizes and spread across the Netherlands. So, a representative group could be formed that offered a wide range of responses during the interviews.

Eighteen municipalities were approached of various urbanity sizes which are familiar with the subject of BSS. Most of these municipalities were in the process of orienting on BSS at that time.

Nine did agree to an interview. Five cities, Eindhoven, Tilburg, Den Haag, Rotterdam, and Groningen were of urbanity category 1: very urban. Three cities, Enschede, 's-Hertogenbosch and Leeuwarden were of urbanity category 2 (strong urban). In addition, the municipality of Houten - category 3 (moderately urban) was selected because of its atypical history of motorized infrastructure. It is dominantly used by cyclists as a result of infrastructure choices in the '70s. The specifications of the urbanity levels are explained in paragraph 1.3, these are based on the number of house addresses per square kilometres.

The structured interviews were conducted in a period of two weeks in March 2018. The goal of the interviews was to collect points of views from municipalities with respect to public values, governance, experiences, (perceived) benefits, challenges and /problems, opportunities and what kind of stakeholders are involved. A list of questions was sent one day ahead of the interview, so they would be aware of the type of questions and the scope. Also, it provides the opportunity to formulate and define the information an interviewee finds desirable to share. The guideline of the interview questions is attached in Appendix H.

All interviews were recorded, transcribed and coded per subject (file available at request). 'Interesting' quotes were added in the file to use in this thesis. A quote would be particularly interesting if it contradicted literature findings or private values.

Afterwards, the interviewees were asked if they agreed with using the information of the interview. Some did not like seeing literal quotes with a name attached to it. So all quotes were anonymized to the municipality level in the public version of this thesis.

Besides the nine interviews with municipalities, also an interview with a dockless BSS operator was conducted in the form of a semi-structured interview in August 2017. The interviewee was the owner of Flickbike, former BSS operator in the Amsterdam region.

Furthermore, a board committee meeting "Council for the living environment" of the municipality of The Hague was attended. This meeting was also used to identify private values because multiple operators (e.g. Obike, Mobike) were questioned on their vision on BSS in The Hague. The goal here was to identify public and private values and how they might conflict.

The results of the interviews will be presented in chapter 4.

2.6 Analysis of conflicts

Firstly, the subjects during the interviews were grouped and important and unique quotes were placed in the text of this subject. These subjects will be presented in paragraph 4.2: 'Public values'. To anonymize the quotes, numbers will be used to identify the corresponding interviewee for the researcher and the committee.

The input of the interviews will result in the identification of public values and private values. These public values will be presented in an overview and sorted on the main subject and underlying sub-value. The number of times mentioned by the interviewees will present the existence during policy making and therefore dominance of that value. This will result in a list of public values.

Private values were identified based on the interview with a bicycle sharing operator and the public committee meeting in the municipality of the Hague. Private interests will not be counted but analysed and defined if this value is present for all operators. If the value was shared by all known operators it could be used for this research, because it will clarify something of shared bicycle operations in general.

Subsequently, the public values will be confronted with the private values and some will provide a conflict, some will not. The conflicts will be taken into account for further research. This overview of conflicts answers subquestion 2.

As shown in figure 2, the answers of interviewees will be substantiated by data gathered from Flickbike. For instance, by whom the system was used and for what kind of trips the system was used can clarify the worries of the interviewees and sometimes reduce the degree of severity, to use the conflict for the design phase.

2.7 Data analysis

The owner of Flickbike, Vikenti Kumanikin, was contacted if he was able to share the trip data of his scheme of 1000 shared bicycles in the summer of 2017 in the city of Amsterdam. Users could unlock the bicycles with an application for Android and iPhone with this BSS.

This data could be retrieved if it was anonymized, so it could no longer be traced back to individual users. Because Flickbike promised to the municipality of Amsterdam to share data with the municipality data department and researchers if requested, he agreed to share the dataset of 24.000 trips for this research.

During the period of operation, there were 6.282 registered users (van Waes, Münzel, & Harms, 2018). The data was sent in a raw data file as a comma separated values (.CSV) file.

Statistical data analysis was executed on the file. To gather interesting information about the time of the day it was used and user specification, because the place of residence was known. This could provide information if the system was used by inhabitants or tourists.

This statistical analysis will give some general insights into the possible usage of BSS in the Netherlands, of which little to nothing is known to this day. But most importantly, this information can be a completion on presumptions of interviewees stated during the interviews.

In other words, the data can be used to check if the identified conflicts are conflicts in reality.

The results of this data analysis are presented in paragraph 4.3.2 and Appendix I.

2.8 Design

The input for this phase of the research will be the conflicts that are identified as the most challenging and important based on the interviews and subsequent analysis. This will result in four urgent conflicts that are used for the design phase in chapter 5.

The design approach will be based on 3 pillars:

- International literature
- The initial system model
- Interviews

The four conflicts will be assessed based on these pillars and governance measures will be purposed to cope with these said conflicts. Although the research question will answer the coping measures for municipalities, a higher level of government or institution can play a role in these measures, so will be taken into account. For instance, a higher government introduces a measure to regulate the bicycle sharing market.

This chapter will answer subquestion 3.

2.9 Wrap-up

In this chapter, the method framework is presented and every 'method block' of figure 2 is explained and elaborated on in paragraph 2.2 – 2.8. The literature review, subject-related meetings will result in the initial system analysis. These together will answer subquestion 1.

The interviews with municipalities will result in the identification of private and public values, which together with the analysis of bicycle sharing data will identify important and dominant conflicts. Therefore these elements will answer subquestion 2.

The found conflicts will form an input for the design phase in which coping measures for municipal governance can be identified to solve or limit problems before or during the introduction of free-floating bicycle sharing in a city. Therefore, this last phase will answer subquestion 3.

The next chapter will introduce the theoretical foundation of this research.

3 Three streams of literature

In this chapter, the literature that is used for the research is discussed. It consists of three themes that form the theoretical framework for the following chapters. *Sharing platform literature*, *Mobility literature and Governance literature*. This chapter partly provides answers to subquestion 1 and provides a basis for subquestion 2 and 3.

3.1 Structure literature

As shown in figure 3, there are three main themes as a fundament for the literature review. Sharing platforms as defined in the sharing economy framework by Frenken et al. (2015) and what bicycle sharing is in the context of sharing economy is elaborated on in paragraph 3.2. In paragraph 3.3 mobility theories in the context of bicycle sharing are discussed, which shows the differences between dockless and docked bicycle sharing. In paragraph 3.4 the governance fundament is explained focussing on public values and the private company values.

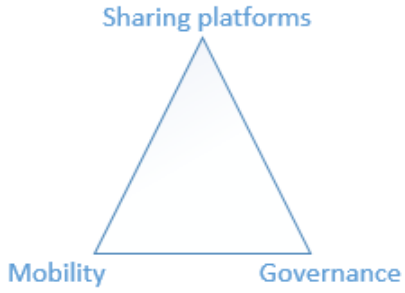

Figure 3: Literature triangle

The three themes of literature as stated in figure 3 are chosen because these can provide important insights into the characteristics of sharing platforms and thus also in the function and developments of BSS. If it is understood what the fundamental elements behind sharing platforms are, BSS can be categorized accordingly. In addition, it is important to understand the contribution and characteristics in terms of mobility. Because the appearance of a BSS can have different implications for user mobility options. The literature behind governance will clarify public and private values and will give the fundament for designing coping measures.

3.2 Sharing Platforms

The *sharing economy* is a relatively new societal phenomenon gaining popularity since 2012 (Google Trends, 2018), it is usually associated with non-materialism and the social aspect of using products.

If one evaluates companies and initiatives that emerged in the past decades, not all companies fulfil all prospects of a sharing economy. Frenken et al. (2015) developed a framework by which the different sharing economy claims from businesses could be assessed. The three elements that must be present to be considered as part of the sharing economy:

- *Consumer-to-consumer*(C2C); it is not about renting or leasing a good from a company.

- *Temporary access*; it is about access to the good, thus not about changing ownership.
- *Physical assets*; it is about using physical objects more efficiently. It is not about people, because they cannot go unused and physical goods can.

So if all of these elements are present in an initiative, it is considered the purest form of sharing economy. If some elements are at hand it can be related economies:

On-demand economy, second-hand economy or product-service economy, which will be illustrated in figure 5.

Shaheen et al. (2010) introduced an overview to assess different types of shared mobility initiatives. Besides bicycles, cars, motorcycles and other modes of transport can be shared. The key element is that short-term access is provided to the user on an as-needed basis. Besides the physical modes, also rides can be shared. All these initiatives contribute, to a certain extent, to innovative transportation and thus enhances urban mobility. Figure 4 shows this subdivision and one can conclude that bicycle sharing is not a phenomenon on its own but originated alongside all kinds of other forms of mobility initiatives.

The city of Amsterdam has also seen these other forms in recent years, scooter sharing in the appearance of Felyx (Gemeente Amsterdam, 2017) and ride-sourcing in the appearance of Uber. This also gives some thoughts about uniform regulation or at least lessons learned from other types of shared mobility for the subject of bicycle sharing. For instance, carsharing is monitored and best practices are shared amongst municipalities by several institutions. Platform Autodelen (2018) is such a platform, to both promote and improve the introduction of carsharing.

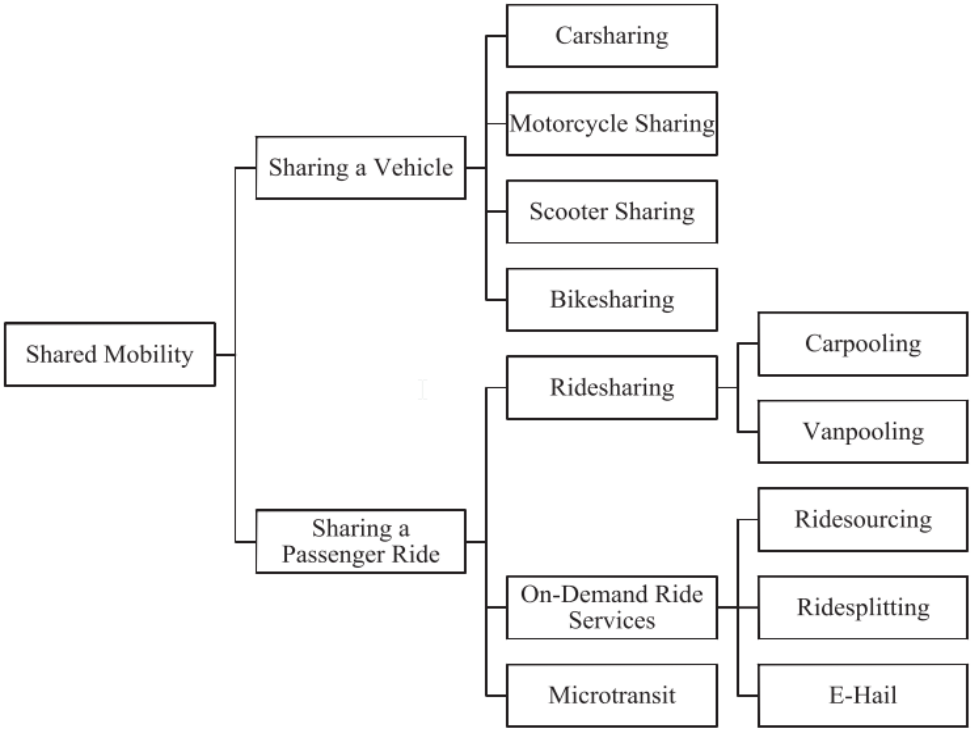

Figure 4: Shared mobility overview by Shaheen et al. (2010)

Fietsberaad CROW (2017) distinguished three different forms of bicycle sharing: back-to-one (B2O), back-to-many (B2M) and free-floating (FF). Defined by the *physical infrastructure, return possibilities* and *flexible use in public space*. In this research, the focus is on the dockless appearance of bicycle sharing, in which geofencing is defined as the fourth form of appearance. Free-floating and geofenced BSS are both dockless appearances. In paragraph 3.3 the four forms of bicycles sharing are visualized and explained in more detail. The mobility application per appearance is also elaborated on.

The shared mobility overview in figure 4 only shows the initiatives in the mobility domain. Outside the mobility domain, sharing platforms exist as well. Frenken et al. (2015) developed a model to assess these initiatives as explained earlier in this paragraph. These elements are illustrated in figure 5 with the terms: C2C, access and goods. This figure assessed a couple of initiatives of the sharing economy in the Netherlands. Arets (2018) monitors and defines the state of the sharing economy in the Netherlands and publishes this on www.deeleconomieinnederland.nl, this shows that besides a lot of mobility schemes also schemes are developed in the food, space, services and knowledge sector.

To clarify some Dutch initiatives in the sharing economy, car and bicycle-related platforms are assessed on the framework of Frenken et al. (2015) and shown in figure 5.

Figure 5: Sharing platforms for cars and bicycles: an application of Frenken & Schor (2017)

In figure 5 on the left, four platforms are assessed in the framework relating to car use. One can buy a second-hand car from someone at *eBay*, you can hire someone to drive you with *Uber*, it is possible to share a car with temporary access form an individual with *MyWheels*. Lastly, *Car2Go* enables people to get access to electric cars in a city. This means all these car-related platforms represent a different form of the sharing economy landscape.

If we look at the application of the framework for bicycles there are also multiple platforms in various forms of the sharing economy existing in the Netherlands, as can be seen in figure 5 on the right. You can buy a second-hand bicycle (Marktplaats), you can rent a bicycle from a traditional bike rental company (MacBike), you can hire an individual to cycle you (Fietstaxi), you can rent a bicycle from a private individual (Spinlister) and use forms of product-service economy like *Nextbike* in Maastricht, *Mobike* in Rotterdam and Delft and *Swapfiets* in multiple cities.

There is uncertainty to what extent the sharing economy can contribute to a sustainable society. There have been no comprehensive studies on the sustainable effects of the sharing economy (Frenken & Schor, 2017).

The insights of the mentioned research in this paragraph shows that bicycle sharing is a form of shared mobility that was introduced alongside other types of mode sharing. Experiences during the introduction of carsharing might be of interest if measures are designed for bicycle sharing. The application of Frenken et al. (2015) shows that bicycle sharing initiatives like Nextbike and Mobike are a form of the product-service economy because no peer-to-peer element is present within these schemes. Therefore, the BSS of interest in this research should be evaluated with that in mind. Some opponents of BSS will argue that these schemes cannot be seen as sharing initiatives, but it does contain elements to contribute in terms of *temporary access* and *more efficient use of physical assets*. A peer-to-peer scheme like Spinlister, in which private bicycles are shared, does have all elements of the sharing economy but several experts clarified that these schemes are not profitable and does not have the flexibility and network aspects to become a successful mobility scheme (Fietsberaad CROW, 2017b).

3.3 Mobility

The generations of bicycle sharing as mentioned in the introduction of this research were strongly driven by technology developments like mobile phones, smart cards and credit cards. These lead to more advanced schemes since the first 'white bicycle plan' in 1965 (P. DeMaio, 2009). The introduction of first coin-based payments and later smart card payments, credit cards and QR-code technology also increased the flexibility of the systems (Shaheen, Martin, Chan, & Cohen, 2014). Since the first schemes had a lot of issues with vandalism and theft the introduction of GPS technology contributed to the traceability and rebalancing of the bicycle fleet and later schemes were thus more capable to control the fleet. The introduction of smart locks, which enabled users to unlock a bicycle with their mobile phones, made it possible to create dockless schemes. All these developments also improved the mobility options for users, since the dockless appearance enables users to park their bicycles closer to their destination. A docked station obligates a user to leave from a location which is not his origin and go to a docking station which is usually not his destination (Fietsberaad Vlaanderen, 2017).

Appendix C elaborates on the spatial impact of different modes of transport. Many mobility experts have pointed out that the spatial impact of a car is comparable to twelve bicycles. This is also why many cities are considering mobility options with less spatial impact in the inner

city. It also shows that docked bicycles need almost double the space of a dockless bicycle because the docking stations require a more physical infrastructure (ITDP, 2013).

If cities are going to expand the car-free inner cities they have to provide an alternative for their inhabitants. This is also stated in a report of the city of Rotterdam, shared bicycles have the potential to contribute to chain mobility and first and last mile solutions (Gemeente Rotterdam, 2019).

The municipality requires the operators to use public space properly. And that they want to be a good addition to the current mobility offer and not just have a 'second revenue model', like selling the data generated by bicycle sharing users (Sprout, 2018). The question is whether a second revenue model is desirable, but without a second revenue model or government contribution, it is often not profitable to exploit a sharing system (DeMaio, 2009). But if data is used at a meta level, this is potentially a positive addition to existing mobility knowledge and can therefore also be of added value for the city (O'Brien, Cheshire, & Batty, 2014).

Figure 6 shows the four identified mobility appearances of station-based and dockless bicycle sharing schemes. These types of BSS are shortly explained.

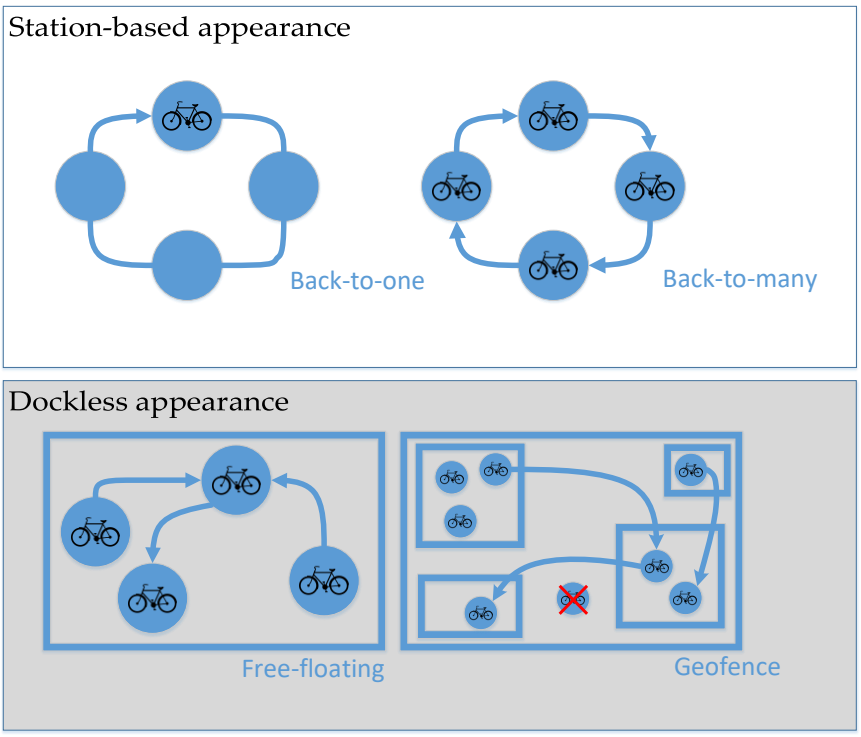

Figure 6: Appearances of bicycle sharing

Back-to-one - In this station-based appearance users are obligated to bring back bicycles to locations where it was initially picked up. The PT-bicycle of the Dutch Railways (NS) is such a system. This PT-bicycle cannot be identified as a pure BSS in the definition of this research because it is not 24/7 available and the pricing scheme is based on a compulsory rental period of one day. This limits the flexibility for the user and is, therefore, no solution for very short distances and the first-mile option to a public transport hub.

Back-to-many - This station-based appearance allows the user to bring back the bicycle to multiple locations. This contributes to the flexibility in use but still has some limitations to the use of bicycles in comparison to a private bicycle. The docking stations should be very close to the origin of the user and also close to the destination of the user. If the docking stations are not within the catchment area of a certain group of users the mobility contribution is limited (Krizek & Stonebraker, 2010).

Free-floating - This dockless appearance allows the user to park the bicycles everywhere within the operating area of the BSS. Only the outskirts of the operating area are usually identified by the operator. This means that the users of this type of system have a lot of flexibility and can park and use bicycles freely, similar to mobility patterns using their private bicycles.

Geofence - This dockless appearance limits the user's ability to park a shared bicycle everywhere within the operating area in comparison to free-floating. Digital fences are allocated within the operating area to park the bicycles. Operators can obligate the users to lock the bicycles within the geofenced areas. This geofence has the potential to become a useful enforcement tool for operators and municipalities.

In figure 7 an overview is given of business models, appearances and examples currently operating in the Netherlands. This illustrates why the different terms for bicycle sharing are sometimes used interchangeably and create confusion.

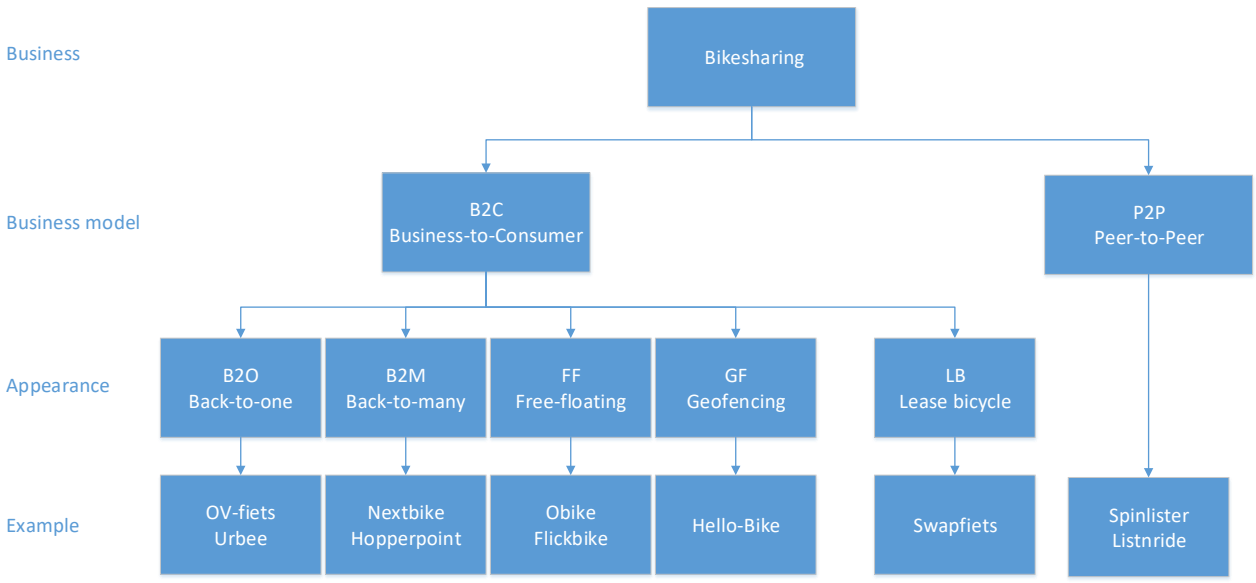

Figure 7: BSS in the Dutch perspective

Midgley (2011) executed research on the role of bicycle sharing in urban mobility and identified the trip costs and trip lengths in comparison to other modes of transport. As can be seen in figure 8, he concluded that bicycle share trips are typically short and considerably shorter than private bicycle trips. This should be taken into account if BSS is intended to become an alternative for private bicycle ownership.

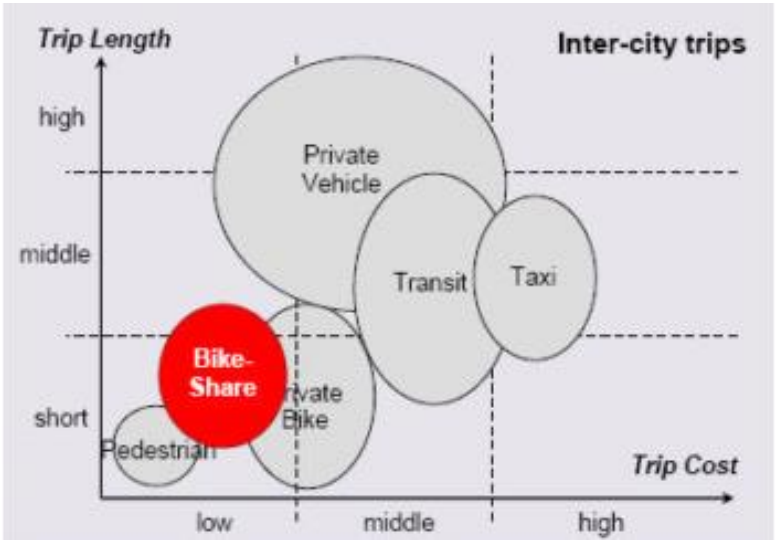

Figure 8: Bicycle sharing trip length (Midgley, 2011)

Reiss & Bogenberger (2015) analyzed and illustrated the use of a free-floating BSS during the workdays and weekends. This research was based on a scheme in Münich, Germany. As can be seen in figure 9, there are clear differences in use during workdays and weekends. The peak hours during the workdays, Monday till Friday, can be clearly identified. This usage clarifies that the system was also used by inhabitants and commuters of the city. The weekend trips showed an increase in usage during the day with a peak in the afternoon. The peak hour usage on the workdays was higher than the highest usage peak on the weekends.

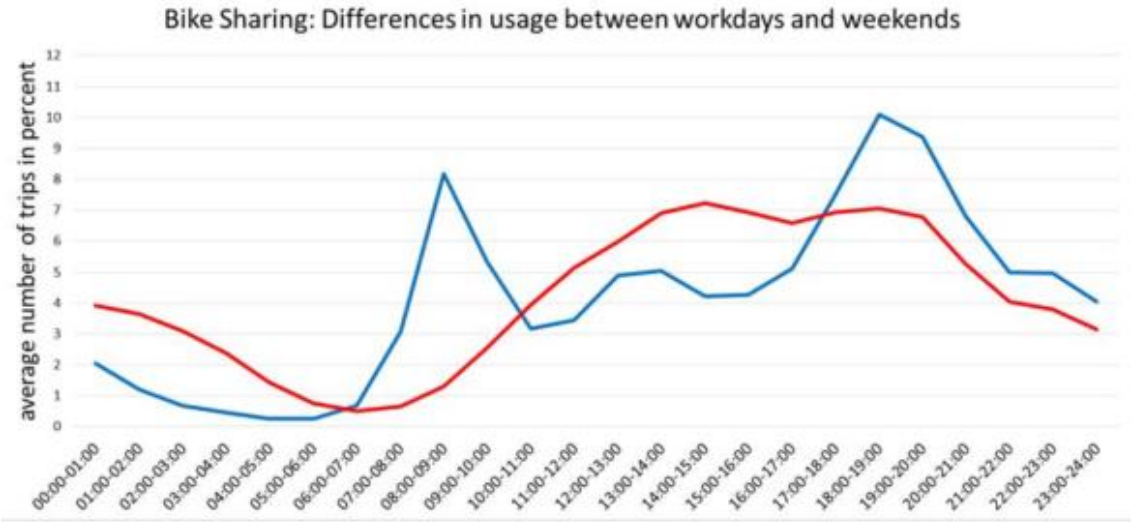

Figure 9: Usage pattern BSS in Munich (Germany) by Reiss & Bogenberger (2015)

3.4 Governance

There are many cities all over the world that struggle to cope with free-floating bicycle sharing. These regulations come in many forms and the process of these developments are also very variable. Some cities were surprised by the arrival of BSS, others developed regulation in advance or had meetings with the operators during the implementation to cope with the phenomenon. The city of Seattle did develop a *permit requirement* document with many elements to meet by potential operators, which is attached in Appendix D (Seattle Department of Transportation, 2017). The city of Dublin adopted *bye-laws* to cope with 'stationless on-street bicycles' (Dublin City Council, 2017). The city of London introduced a *code of practice* to ensure well-designed BSS in their city borders (Transport for London, 2017).

In general, three types of possibilities to cope with initiatives are present for authorities in order to regulate the market. These are:

- *Prohibit/Enforce* (Rules and regulations), hard regulations in which clear rules are enforced by authorities. This is the most direct form of regulation.
- *Pricing* (Incentives), pricing incentives can be introduced to compensate for indirect costs as a result of the business in the private market. One can think of sufferance taxes for terraces.
- *Inform/soft regulation*, soft regulations to cope with issues are more easily implemented and executed and can be very useful. Municipalities can play an essential role in communication programs towards the public in relation to embracing initiatives and public opinion.

Since dockless bicycle sharing in relation to bicycle sharing is identified as a *product-service economy.* This means that *private values* are incorporated in the business models. Since these private values can conflict with public values, this is of importance for this research. This brings up the question to what extent these systems add value and are of importance for society. These values can be distinguished as *public values.* These values are widely discussed in many articles. But there is not one definition that unanimously expresses the concept. Therefore some important points of view on public value are stated to come to a definition for this research.

Charles, de Jong, & Ryan (2011) argue that there are three important macro-economic forces leading to public values; *economic ideology*, *political integration* and *technological development*. This can be described as generalized goals defined by authorities to strive for society. So this makes clear that pursuing these goals are of importance for policymakers.

The first researcher that mentioned public values was Moore (1995) who stated public value as follows in relation to public sector enterprises:

"The definition that remains equates managerial success in the public sector with initiating and reshaping public sector enterprises in ways that increase their value to the public in both the short and the long run."

What can point out from this definition is the importance of public value to contribute in the long run, not only quick wins for policymakers. Another research stated that public values can

be defined as "deeply felt needs and wishes that citizens have regarding the delivery of services, such that they are in effect deemed essential" (Kelly, Mulgan, & Muers, 2002). This can be interpreted as services that ultimately fulfil the desires of inhabitants, who are represented by authorities.

Veeneman & Koppenjan (2010) gave substance to public value by stating:

"Public values are values that all inhabitants together expect to be secured in our society, these values can be very abstract or operational in form."

This means that values are not only themes like; *sustainability* or *efficiency* or very concrete objective like *contribution to employment*. Public values can also be very specific and therefore operational.

Charles et al. (2011) also added that public values are deeply desired needs and wishes by society delivered by the service of attention. This public value can be fulfilled by private companies, on behalf of the public sector or solely by the public sector.

Based on discussed literature the following aspects are taken into the definition of public value:

- Public values are *needs* and *wishes*
- Public values are also for the *long run*
- Public values fulfil the *desires of inhabitants*, represented by authorities
- Public values can be *abstrac*t and *operational*

This definition that is used in this research for *public values*:

"Public values are the needs and wishes of inhabitants for the short and long term, pursued by authorities and can be abstract and operational"

As Charles et al. (2011) noted, public values are not universal, change over time, context and development of society and technology. This research establishes contemporary states of the public values, actually present in the stakeholders. Once these public values are identified, governance of the schemes can be designed that contributes to secure some important public values.

3.5 Wrap-up

This chapter viewed the literature and research known about bicycle sharing relevant for this research. This literature will also contribute to the system overview in paragraph 4.1. Together with this chapter, these will answer subquestion 1. As stated in paragraph 3.1 the literature presented was based on the three elements: *sharing platforms*, *mobility* and *governance*. The most important findings per element will be shortly recapitulated:

Sharing platform derived from the phenomenon of the sharing economy, which is classified as purely sharing economy if it is shared from *consumer-to-consumer*, *temporary access* is provided

and *physical assets* are used more efficiently. Dockless BSS only contains the second two elements and is therefore defined as a *product-service economy* scheme.

The *mobility* contribution for users is strongly dependent on the appearance of the scheme. Station-based schemes have limited flexibility in relation to the origin and destination of their trip. Dockless appearances provide this flexibility for the user and are therefore more attractive to use.

Governance for BSS can come in many forms. Cities worldwide have already introduced service level agreements, memoranda of understanding, codes of practice, bye-laws and codes of practice. But in general, authorities have three starting points: *prohibit/enforce*, *pricing* and *soft regulation.*

Public values are defined in this research as the needs and wishes of inhabitants for the short and long run, pursued by authorities and can be abstract and operational. If the measures to cope are designed by pursuing these values, this will contribute to better BSS in general.

All literature combined shows us that bicycles sharing systems are an appearance in a wider phenomenon of sharing platforms and in which new technologies enable companies to let individuals share products like bicycles. These sharing platforms are for-profit business models which can add to new mobility options and also generates user data that can be of value for third parties. BSS can come in many forms and the specific design in terms of appearance is of major influence on the mobility attribution of individual users. Free-floating systems will be able to become a first- and last-mile solution, where a less flexible appearance has limited first-mile potential. Authorities will have to clearly define what a BSS in their city should contribute to, before putting governance options in place. To strong regulation can limit the functionality of the systems.

4 Results

Now both the methods and literature are explained, this chapter will present the results of the research methods. As explained in paragraph 2.1 the objective is to find conflicts between public and private values that can be used in the next design phase. Identifying these conflicts will help to give an answer to the main research question on how to cope with public-private friction. Firstly, this chapter will start with the initial system analysis, based on the theories, prior literature and subject related meetings. Secondly, ten themes are discussed with quotes of the interviewees as sources of the findings. Thirdly, from these findings, public values and private values can be identified. Fourthly, Flickbike data is used to substantiate the views on public and private values. These steps will result in the identification of the most dominant conflicts between public and private values to cope with in the design phase.

4.1 System overview

The causal system overview in figure 10 shows the findings based on the literature of chapter 3 and the subject related meetings as described in paragraph 2.3. To structure the findings in literature and case related meetings, a model was developed to describe the implementation of a BSS in a Dutch city. It provides a means to understand the factors of influence of a municipality and other stakeholders in a system in one overview. It should be noted this was based only on findings of existing literature. Perspectives gathered from the interviews might call for the adaption of the model. This will be discussed in chapter 5, Design.

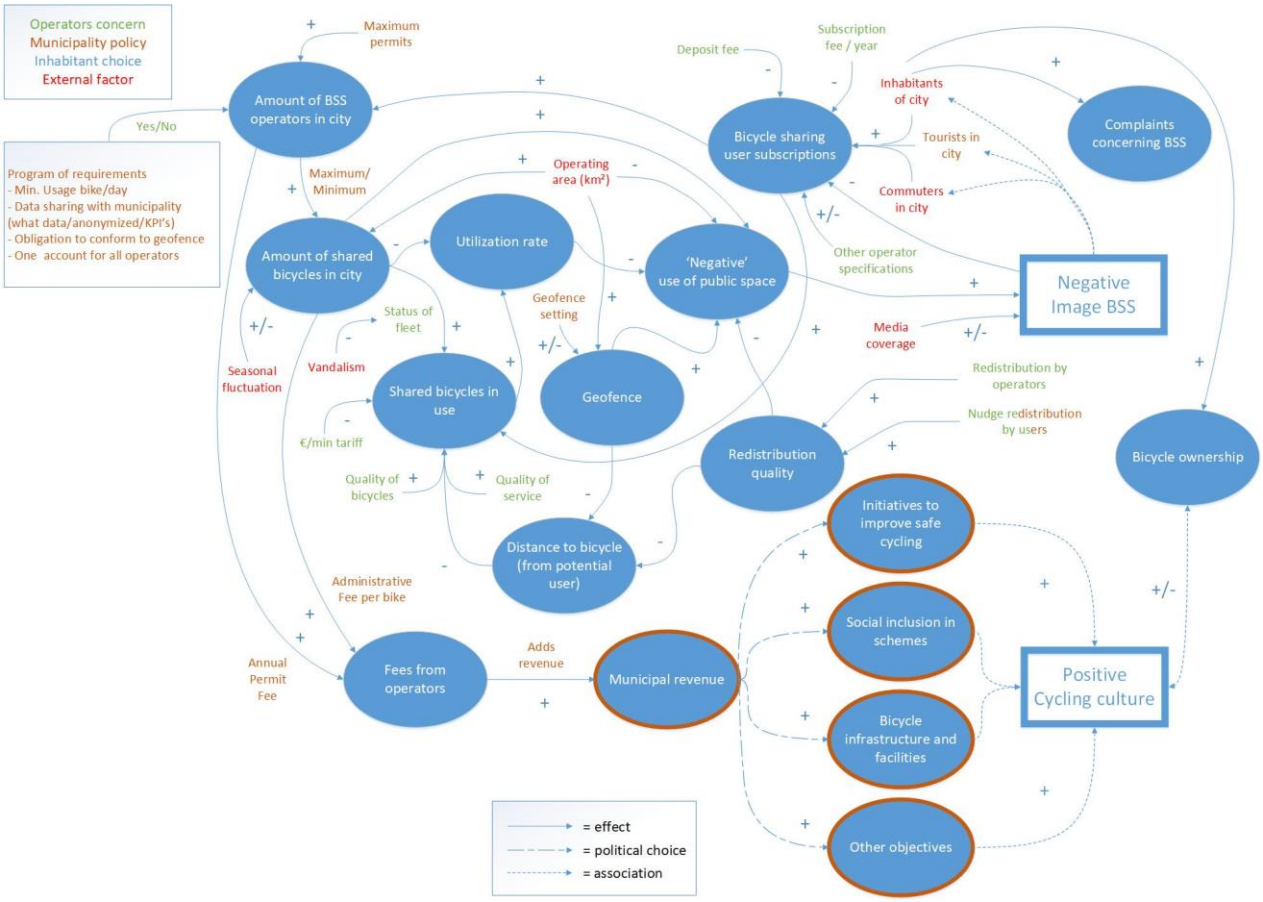

Figure 10: Initial system analysis

Aspects playing a role in this scheme.

- *Factors*: These are elements decided, governed or caused by a particular stakeholder. In this model: operators concern, municipality policy, inhabitant choice or an external factor.
- *Measurable output*: These aspects are influenced by the factors, like utilization rate and use of public space. These elements are all measurable and can, therefore, be a useful starting points for key performance indicatiors (KPI's) or permit requirements.
- *Output images*: These aspects are influenced by the factors and measurable output, directly and indirectly. The Image of BSS and Cycling culture are the two images in this model. Also, they can't be measured accurately and therefore are not useful as direct KPI's or requirements to steer for as a municipality.

Together they create a network on which possible governing measures can be checked for influence or coping measures can be designed for. As discussed in paragraph 3.4 there are three main governance strategies: *enforce, pricing and soft regulations*. Figure 10 shows on what factors municipalities could govern. The factors geofence setting, number of operators in the city and program of requirements are suitable to enforce. Annual permit fees or administrative fees per shared bicycles can be calculated for the operators, which would be a pricing strategy. Soft regulation can be executed in the form of communication to the inhabitants to nudge for desired behaviour, which has a positive effect on the factor 'negative use of public space' as included in the model.

This scheme gives insight into the most dominant aspects of the scheme and attributes of the system that can be adjusted or requirements can be developed for. Therefore this scheme also created a starting point for the questions asked in the interviews with municipalities.

A more detailed description of the scheme can be found in Appendix F, together with clarification of each factor. Now follows a description of the most important aspects based on the model.

Amount of BSS operators - A municipality should think about the number of operators that is desirable in a city, more operators are good for competition on service and quality of the bikes and differentiation in the type of bikes is good for potential users and specific user characteristics. English operators are claiming that two operators are a maximum for a city with less than 150.000 inhabitants (Bikeplus, 2018).

Amount of shared bicycles - The number of shared bicycles is important to consider because of the impact it has on the public space and the number of bicycles that is needed for the people to improve their mobility and accessibility to the closest shared bicycle (ITDP, 2013). The municipality could monitor the fleet size and the performance of the system in terms of utilization rate to reach a combined optimal fleet size (fleet of the permitted operators combined).

Shared bicycles in use - The number of bicycles that are used on a regular basis. This is fluctuating over time and should, therefore, be evaluated with that in mind (Zhang, Brussel, Thomas, & Maarseveen, 2017). Also, weather and seasonal factors should be studied to review

performance. But can also influence the number of bicycles in the city during a certain season (O'Brien, Cheshire, & Batty, 2014).

Utilization rate - Internationally many operators do not report usage rates of their fleet. Some operators who do report, have a very wide range of trips/bike/day (E. Fishman, Washington, Haworth, & Mazzei, 2014). On a continuous scale, this would result in a utilization rate of the shared bicycles, this would be calculated by 'bicycles in use' divided by the number of shared bicycles in the city

'Negative' use of public space - This factor is important for the BSS design because authorities have a growing interest in how public space is used and to what function it is allocated. This factor is therefore connected to the utilization rate. In relation to BSS, the use of space is negatively associated when bicycles are not used for a longer time and occupy bicycle parking space. The use of public space when bicycles are used riding on the road are positive for the functioning of the system and are therefore associated positively by the public.

Bicycle sharing user subscriptions - The current bicycle sharing operators are working with subscriptions. The fee for deposit is varying per operator. Some are using discounts for students or at certain action periods, they are lowering the fee. This fee is mostly presented as a deposit for good behaviour with the bicycles and to not return the deposit if the user is to blame if the damage is found to the used bicycle. Based on the three potential users of a BSS; inhabitants, tourists and commuters. In Barcelona, the city decided that the BSS could only be used by inhabitants (Murphy & Usher, 2015).

Redistribution quality - With the quality of redistribution is meant the distribution of bicycles over the city in relation to potential users in the city and the distance between the bicycles. The better this fleet is redistributed over the operating area, the better the bicycles will be used, which contributes to a better utilization rate. This redistribution can both be conducted by the operators or by the users by using nudges, see an example of Mobike in Appendix E. The redistribution quality is based on the effort the operators make to re-balance and remove wrongly parked bicycles into the allowed geofence area. This redistribution quality factor is the fraction of bicycles that are not in use and is located within the geofenced area. So, if 95% of the bicycles is within the geofence, the redistribution quality = 0,95. Also, the optimal distribution is taken into account in this factor.

Fees from operators - Authorities of a city could think of introducing fixed fees for operators with a BSS in the operating area. These fees can consist of an annual permit fee per operator for the overall operation (Seattle Department of Transportation, 2017). Based on the fleet size of the operator an administrative fee per bike can be established which obviously will be more if the operator wants to grow in terms of fleet size. Still, the authorities can set a maximum per operator to reach an optimal functioning system. The legal justification for these fees could lie in the fact that public space is used for commercial activities and extra monitoring by civil servants and therefore an operators fee for the use of public facilities and workforce can be legitimate.

Investments in bicycle-related subjects - Since policymakers and operators have a common interest in good cycling behaviour and qualitative cycling facilities. The collected fees from operators can be reinvested in cycling related subjects to improve the overall cycling culture. The direct investment in related facilities and programs for improving the cycling culture can create goodwill by the operators, inhabitants and other stakeholders (Vélo Mondial, 2018).

Geofence - A geofence can be part of the program of requirements where operators have to conform to, to get a permit/license for operations. This geofence is a digital 'fence' determined by the authorities where the shared bicycles are allowed to be parked. Geofences can be very small and local or the total operating area can be surrounded by a geofence, which keeps the bicycles within range for maintenance and redistribution (Gemeente Amsterdam, 2017).

Complaints concerning BSS - The complaints concerning BSS are mainly raised by negative experiences of inhabitants with shared bicycles in the city. They are an indication for the degree of acceptance in a city and how well the BSS is functioning in terms of disturbance and nuisance in the city. The municipality should be aware of opponents using the same pictures of piled up bicycles as a strong opposing force. The complaints by inhabitants are indirectly formed by the negative image created by the media and the 'negative' use of public space. Nevertheless, in this model inhabitants are described as the number of inhabitants and the positive effect the increase of inhabitants has on the number of complaints concerning BSS.

The aspects of the model that are discussed give a first indication of what kind of topics were important to discuss with the interviewees of the municipalities. Therefore, this model was used to create a list of questions to use as a guideline during the interviews, as discussed in the next paragraph. The complete list of questions can be found in Appendix H. A more extended version of the factors included in the initial model can be found in Appendix F.

4.2 Public values

Table 3: Cities included in this research

Reference Number	City	Urbanity	Inhabitants	Cycle mode share <7,5km
1	Enschede	2	157,864	35%
2	Eindhoven	1	226,868	32%
3	The Hague	1	526,439	25%
4	's-Hertogenbosch	2	152,411	30%
5	Tilburg	1	213,804	32%
6	Groningen	1	202,636	46%
7	Leeuwarden	2	108,667	42%
8	Houten	3	49,300	37%
9	Rotterdam	1	643,660	23%

Interviewees responded to the questions as attached in Appendix H. Based on the structure of the interviews, the answers given are coded according to ten main themes. Numbered references refer to the numbers of interviewed cities in table 3. More information about the interviewed experts can be found in Appendix G. In this result paragraph defining quotes related to the theme are illustrative for the municipalities interviewed and give input for the identification of the *public values*. The identified public values, if there were, are included at the end of the paragraph.

The interview themes are discussed in the following sequence: *Cycling culture, Mobility, Functionality, Users, Stakeholders, Public Space, Data, Costs, Regulation and Sustainability*

4.2.1 Cycling culture

All nine cities argue that their current cycling culture is good enough, but all see room for improvement. Typical themes of the past years are cycling flows, taking away infrastructural barriers for cyclists and 'branding' of cycling routes. [1-9] Bicycle parking is a major issue for many cities, increasing bicycles ask for improved and increased parking spots. [3,4] Fast cycling routes are implemented to encourage commuting by bike between city centres. [1,4,7] In addition, cities are experimenting with innovations, so-called living-labs to test new concepts. BSS is seen as such a new innovation and all cities are open to pilot projects or at least sharing knowledge about the new concepts. [1-9] Also communication programmes, to encourage cycling, has become a much bigger theme last years. [1,2,5,7] Two respondents noted that the culture shift from ownership to usage has still to be proven in reality. [7,9]

"It would be great if it fits the city well, for instance, that a BSS expresses the culture of Leeuwarden" – Leeuwarden

4.2.2 Mobility

All municipalities mention that the implementation of a shared bicycle system should contribute to the mobility options of their inhabitants. [1-9] This contribution can be realized because of the flexibility of the system, eight respondents argue that a dockless system has as the main benefit that it is flexible. [1-8] The flexibility also means that it fits more into the origin and destination of users. Docking stations would mean a user starts were that person is not coming from and the trip does not end at its destination. [3] Dockless bicycles potentially better fits the mobility pattern of a user. In terms of the effect of mode share of cycling, seven respondents do not expect a major effect on the modal split of cycling. Two respondents do expect an effect on the modal split of cycling. [2,4]

"I don't expect enormous changes in the modal split, due to bicycle sharing" – The Hague

"Expects a substantial contribution to the modal split of cycling" - Eindhoven

Dockless BSS can also be a very good extension of public transport. [1-6,8] The success of the PT-bicycle shows the potential of last-mile transportation. [8] The dockless bicycle can also play a role in the first mile towards a PT-hub. [3] BSS can also become a part of a concession itself, two cities mention that provinces are investigating the options. [2,4,6] It is stated that this would mean it contains public funding, which is one of the things private dockless BSS initiatives potentially minimizes. [6]

MaaS integration is an important aspect of the future of mobility. [1,2,4,5] It is mentioned that the innovation of BSS must be integrated into future MaaS platforms, so it becomes part of the total mobility supply. [1,2] It also can contribute to less mobility poverty in less prosperous neighbourhoods, although it is considered less of an issue in comparison to the United States, where equitable distribution of service became an issue. [3,6,7] It is a point of attention to demand from operators to cover a complete city and not only focus on the most profitable hotspots. [3,6]

Interoperability was an important theme for the ministry of Infrastructure and Environment. Therefore they initiated an interoperability letter of intent, which is signed by 9 operators. It was also named by five of the municipalities. [2,4,5,6,9] The outline and possible future for interoperability are drafted in a report by Dirk Jan de Haan (Enigma, 2017).

"Mobility especially improves if interoperability has become reality, which is the goal of several BSS operators who have signed a letter of intent for the future" – Groningen

Multimodal transport

Since the shared bicycles normally are used for very short distances, the bicycles can function as a first or last mile solution. Therefore, seven interviewees mentioned the need for connection in combination with prior transportation. [1-6,8] Bus stops, train and metro stations are all potential hubs to attract a lot of BSS users. Also mentioned are a combination of car and bicycle, parking a car at the outskirts of a city and continuing their journey by bicycle. [7] The use of dedicated car parking spots supplemented with shared bicycles can be a solution for visitors to get around inner city congestion. [6] Already existing P+R facilities can also be interesting spots for shared bicycles. [6]

"Especially in combination with public transport or as a substitution for longer walking distances. I don't think it is a substitution for the car, but it can be combined with P+B" – The Hague

The mentioned public values within this theme are:

- Flexibility
- Public transport addition
- MaaS integration
- Increase bicycle usage

4.2.3 Functionality

The functionality of the system is mostly defined by the ease of parking, the availability and the quality of the bicycles. [1-9] The quality of the bicycle is mostly defined as the weight, height and comfort level of the shared bicycle. The ease of parking closely relates to the possible implementation of geofence technology, which is discussed in paragraph 5.2.9.

"But we also believe it is important to have a good quality of bicycles, quality of service and acceptable pricing" – Leeuwarden

The price setting per trip is also an important element, one of the regularly heard arguments is that is must have a competing price with the PT-bicycle. [2,5,8] In addition, the quality of service is identified as an important element because of the possible complaints, technical support and communication channel for non-users. [5] The ease and quality of the corresponding mobile application are also important for the functioning of the system, for instance, how easy it is to make an account and subsequently unlocking the bicycle without prior knowledge. [1,7,9]

The initial payment or deposit that is required to use the platform varied between 0 – 75 euro depending on the operator. From a user perspective, this is a barrier to use the system and is preferred to keep as low as possible. [3] Also varying per operator was putting money into a digital wallet prior to the use or not, some asked for an initial deposit, others did not.

"Pilot size does affect the functionality of the system" – Groningen

Finally, the amount of shared bicycles placed in an operating area is crucial for the functioning of the total system, there is a minimum amount of bicycles needed to serve the users in a city in an appropriate way. [5,6,9] Slightly increasing the number of bicycles from that minimal amount might be better for the adoption of the system. [9]

The mentioned public values within this theme are:

- Quality of bicycles
- Availability
- Pilot size

4.2.4 Users

User perspective

"We try to look at this system from an end-user perspective, they should find it convenient" – Tilburg

From the user perspective, convenience and flexibility are named mostly. [1-9] The users of the system are willing to use the system if the convenience of the system is at an acceptable level, also in comparison to their current bicycle. [2] Otherwise, the benefit of switching to a BSS is not

suitable. Another motivator for potential users can be the absence of private maintenance in comparison with owning a personal bicycle. [8] The same goes for the quality of the bicycle, they should be more closely designed to the Dutch standard of a good bicycle, current BSS bicycles are more suitable for the Asian market. [1-7]

Interoperability can be very useful and give added value for the user, this can contribute to a bigger shared network of bicycles in multiple cities. A user no longer has to make more accounts for different operators. [2,4,5,6,9] This also makes it more suitable to be integrated into future MaaS platforms. The innovation of shared bicycles should ultimately result in the integration with MaaS, several mobility options integrated into one system. [1,2] It might be an option to provide different bicycles for different target groups, so it fits their behaviour best. [1]

It is noticed by three respondents that people sometimes show different behaviour with the shared bicycles in comparison to personal bicycles. [5,6,9] People should in some way feel responsible for their shared bicycle in the same way as they do for their personal bicycle. [5] The user of the system can easily misbehave using the bicycles in an inappropriate way, damaging the bicycles, park at locations where it is not allowed and cycle dangerously while on the public road. [4,6]

"Several operators are planning on implementing a scoring system, if you park near a train station you get a score deduction and you get extra points for removal of a bike from an undesired location" – Groningen

Gamification, in which good and bad behaviour have a positive or negative effect on a score is a possible implementation to steer behaviour. [9] The decreased score can ultimately result in higher fees for use of the system, which can result in a user that no longer is able to use the system, details on how this scoring system is implemented is elaborated on in Appendix J. It is stated by a respondent that this is a quite extreme form of nudging and therefore should be considered carefully. [7]

Potential users

Interviewees agree that a BSS should be there ultimately for the inhabitants. [1-9] Also because tourists currently are using traditional services like bike rental shops. A municipality should, therefore, be careful supporting a BSS, to prevent state aid and competing against their own local bicycle rental shops. [8] A second remark on focussing on local inhabitants is keeping an eye for non-users of the system. [2] It was a frequently heard statement in Amsterdam that the system would be there for the tourists and not for the inhabitants, this will be analysed and addressed in paragraph 4.5 using the Flickbike trip data.

"Tourists are currently served by traditional bicycle rental shops, authorities should be careful with unfair competition" – Houten

Commuters are also an important target group, currently served by the PT-bicycle at the NS railway stations. A more flexible alternative and limited costs can be a good alternative for

commuters. [1,3,4] This really relates to the last-mile solution, bicycles at a public transport hub contribute to multimodal transport.

"Commuters now make use of the successful PT-bicycle (OV-fiets), bicycles at a hub are crucial" – Houten

Special target groups within the group of inhabitants are students and expats. [2,6] Cities with a lot of students are typically bicycle friendly and have a lot of bicycle-related challenges. [6] In addition, students easily adapt to a new innovation like smart lock technology and can function as early adaptors of the system. [2,5,6] The success and quick development of new bicycle subscriptions like Swapfiets or VanMoof show that students are open to new forms of bicycle ownership. [4,7] Some cities also have increasing numbers of expats, like Eindhoven, and therefore also mention the expat as potential shared bicycle user. [2] A moment when an expat enters a city might be an opportunity to steer towards shared use of bicycles. [2]

Regular visitors of a city and employees of big companies are also identified as potential target groups. [4,7] Regular visitors because of their recurring appearance in a city and employees of big companies because they can be targeted by one communication channel and can form a significant amount of users from the total amount. [4]

The mentioned public values within this theme are:

- Interoperability
- Personal responsibility
- Social inclusion

4.2.5 Stakeholders

Users are especially focused on the functionality and costs of the system and that determines if they will use the system. Therefore potential users must be tempted to become users. Non-users are aware of the system and act as an opponent if the new situation causes nuisance, pollution or obstructed pathways. [1-9] Therefore non-users must somehow be satisfied and operators can not completely ignore this group. [5] Policymakers are focused on regulating the public space and want operators to control their fleet of bicycles, authorities can set the regulatory framework in which the operators can do business with their customers. [4,6,9] The BSS operator and potential multiple operators will compete with each other in a 'free market' model, but in a more 'co-operative' model or 'regulated' market, a more predictive supply can be safeguarded. The traditional bicycle rental companies will see the new BSS innovations as a disturbance for their business models, nevertheless, they are mainly focussing on the tourist market, it will act as an opponent when a municipality is decreasing their profits by state aid for BSS.

“Besides external stakeholders, like traditional rental services and end-users, it is also an internal alignment with politics, municipal street designers, bicycle parking enforcement and city-marketing had also interest in the developments” – Enschede

The mentioned public values within this theme are:

- Use by inhabitants
- Use by commuters

4.2.6 Public space

One of the important themes is preserving the quality of public space: incorrectly parked bicycles are considered unwanted and unsafe. [1-9] Cities struggle with the initial increase in the number of bicycles due to the placement of many shared bicycles, without guaranteed success. [1,2,3,6,9] The arrival of the service only creates a possible future of fewer bicycles on the street, if people really put away their 1st or 2nd bicycle.

"An explosive growth in public space, you may lose control in public space" – Enschede

In addition, public space is used to exploit products. This can be seen as 'commercialization of public space', or simply said: public space is used to earn money. [1] Four interviewees, therefore, recognize that sufferance tax, as is the case for terraces, might be an option. [1,4,6,9] For carsharing, a similar tax is implemented, but also has characteristics of car parking permits. [3] Still one could argue that car sharing and bicycle sharing as a product-service have similarities and therefore should be taxed similarly.

"Maybe we will see more products like these entering the streets, so we should be careful with allowing these type of business models because it could set a precedent " – 's-Hertogenbosch

The mentioned public values within this theme are:

- Quality of public space
- Control of public space
- No commercialization of public space

4.2.7 Data

Eight cities see the harvesting of fleet trip data as a possible starting point for improvement of infrastructural changes. [2-6,9] Cycling patterns are currently very difficult to predict and little knowledge and actual information is accessible for municipalities.[9] At this moment most data comes from traditional traffic models, which have a lot of uncertainty incorporated. [9] Inductive loop wires in the road are other currently used measures to get information about the usage of a cycle path.

"Trip data can be very useful as input for infrastructural changes" - Rotterdam

Eindhoven has an open data strategy implemented which enforces many operators of different data generating companies to share generalized or anonymized data to the municipality, public or institutions like universities. [2] It is the question how municipalities can require data and also make it usable for the responsible officials. [1,2,3] A municipality might want to attract more data analysts, like Amsterdam, which has a separate team responsible for data analysis.[5]

Privacy is a task for the operators and municipalities do not have an active role in managing the privacy of data gathered by the operators. Six respondents noticed that the GDPR legislation is currently defining strict regulations for companies regarding privacy. Therefore, this privacy concern is considered to be taken care of by European legislation. [1-3,5,6,9]

"Privacy concern is a challenge for the operators. People choose to trust the operator or not" - Eindhoven

Data that is generated by commercial BSS are owned by operators and personalized data is probably part of the business model.[6] A municipality is not automatically co-owner unless enforced by regulation or bought from the operators. It is unclear what the data would cost for potentially interested parties, but it is mentioned by some respondents that buying trip data is an option. [1,6,9]

The mentioned public values within this theme are:

- Information
- Smart cities
- Privacy, but is covered by recent GDPR legislation. Therefore this public value will not be used for this research.

4.2.8 Costs

Finance

The policymakers doubt if solely trip or subscription fees by users can result in a profitable business model, therefore 'use of data' can be the second source of revenue for the operators. [1,3,5,6,8] Some suggest that scraping user information from their smartphone and making profiles for targeted advertising might be a profitable business using the shared bicycles. [3] But operators do not give insight into how they earn their money. [6]

"A municipality doesn't want to become the owner of the system, it only wants to regulate the market" - Enschede

If the shared bicycles result in many complaints, the city will have to make extra costs to maintain the high quality of public space. [1,5] Also more pressure on the parking facilities can contribute to extra costs. Wrongly parked shared bicycles are normally treated like any other bicycle and removed to a bicycle depot, an owner of the bicycle can retrieve their bicycle for €25 in the Haaglanden area, sort like prices are regular in the Netherlands. [3]

Because municipalities do not want to execute and fully operate a BSS it is questionable whether a municipality can force a high qualitative BSS without a lot of maintenance costs and redistribution effort. [1]

Costs municipality

The arrival of many new bicycles has a major effect on the parking facilities like parking racks and infrastructure. This increased pressure on existing facilities is a reason why some

municipalities argue that operators should pay for extra parking racks in the city, as long as the total amount of bicycles does not decrease. [1,3,4,7]

"Dockless is a variant that is quite flexible, infrastructure does not have to costs a lot, that is an advantage" - Enschede

Municipalities have great difficulty in removing indiscriminately parked bicycles, which costs the city more than it gets in return from people collecting their bicycles. [3] If shared bicycles are used by a large number of citizens this pressure on removing wrongly parked bicycles can potentially decrease. [1,4]

If investments in future parking facilities near train stations can be prevented by a big shared fleet of bicycles, this is a great financial benefit for the municipality. Making such a task part of the permit system might be cost-efficient.[3] In comparison with the docked variant of BSS, the physical infrastructure of dockless BSS is much cheaper. [5,9]

The mentioned public values within this theme are:

- Costs for public facilities
- Costs of parking spaces
- Corporate responsibility

4.2.9 Regulation

Public-private cooperation

"We will develop a kind of licensing system with conditions, but with space for entrepreneurship. The municipality must lead it in the right direction" – The Hague

One interviewee mentioned that giving objectives to potential operators could increase the support among the municipalities.[3] Besides the prevention of inconvenience and nuisance, municipalities should think about giving a task to operators to contribute to policy goals. It is the question to what extent these operators can have the same objectives as municipalities.

Six municipalities are currently considering a kind of permit system. [1-6,9] This can contribute to taking back control over the use of public space and lead the way into a regulatory framework. [6]

The first step of the bigger Dutch cities was enforcing on interoperability of several operators. [2] This resulted in a letter of intent to work together, which shows that initiatives of authorities can have an impact on the operators of BSS. Two big operators, Ofo and Obike did not sign the letter, this can result in putting themselves outside the market. [2,6] It is also a measure which gives smaller operators, or local operators an opportunity to enter the market of shared bicycles. [1,2]

"Interoperability can be beneficial, this can result in users using more than one type of shared bicycle with one account, this is of added value for a nationwide system" – Eindhoven

Legislation

There are multiple legislative options suggested or discussed by the interviewees. The enforcement of the city of Amsterdam was based on a general local regulation in which no commercial goods could be offered from public space. [1] This was used to remove all the bicycles out of the city before starting a future permit system.

"In the long term, it is possible to envision the introduction of a sufferance-like tax, which is used for terraces" - Groningen

A second suggestion is in the form of a sufferance tax, in which a tax is charged per bicycle in operation or per operator in general, in the form of a permit fee.[1,4,6,9]

A third option is a regulation on quality of bicycles, the safety of bicycles or quality of service. This can become part of a concession, tender or contract. Also, a city must consider if they prefer one operator or multiple operators. [1-8]

"We give room for pilots, but 's-Hertogenbosch would feel more for the strategy of Amsterdam in comparison with Rotterdam, prohibit initially and create a regulatory framework subsequently" – 's-Hertogenbosch

Geofence

"I think it is an ideal tool for enforcement, especially if it also has indoor parking coverage. Geofence is going to develop much further than it is now" - Tilburg

All nine municipalities see geofence technology as a suitable regulative tool. Although three interviewees mentioned that it is still a technology that has to prove itself and that in combination with high buildings and indoor parking facilities the GPS-locations are not always accurate enough. [1,3,5] It is also said that ideally, it would become impossible to lock the bicycles outside of a geofenced location. [5] This would decrease the enforcement costs of municipalities of wrongly parked bicycles and increase the quality of the public space. [5] Geofence can also indicate preferred parking locations, which can be combined with gamification elements, for instance, that a score will increase if a shared bicycle is parked at such a location. [6,9]

"Reversed geofence is also an option, in which prohibited zones like city parks and train station zones are indicated in the application and in which users are not allowed to park" – The Hague

4.2.10 Sustainability

Sustainability was mentioned as one of the potential benefits of a BSS. It has to be acknowledged that it was mostly an association with sustainability. Three cities anticipate using BSS as a communication or promotion tool for 'active modes', which are cycling and walking. [1,2,7]

A comment is that shared bicycle trips replacing polluting modes can reduce CO2 emissions. [2] Shared bicycles can contribute to increasing the use of more sustainable modes of transport, a shift from car/taxi/bus to the bicycle. [2]

Shared bicycles, as a result of their equal appearance, are potentially more suitable for the circular economy. [5] But the images of Chinese shared bicycles mountains accumulated in the streets did raise the question to multiple interviewees if this image of sustainability could hold out. [1,4,5,6] Nevertheless all municipalities see the BSS as a possible contribution to a sustainable and innovative image of a city. [1-9]

> "It can contribute to the sustainable and innovative image of the city" – Eindhoven

The mentioned public values within this theme are:

- Air quality
- Use of active modes
- Circular economy
- Sustainable image of the municipality

Now all themes are discussed and specific values are found, the following paragraphs will present the private values, conflict identification and data substantiation.

4.3 Conflicts

To identify the conflicts between private and public values, three aspects will be taken into account. As shown in figure 11, data analysis will be the third aspect to substantiate the identified conflicts. Firstly, in paragraph 4.3.1 the public values will be identified. Private values will be shown in 4.3.2 and this paragraph also contains the data substantiation.

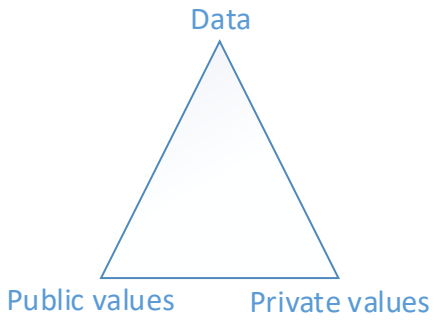

Figure 11: Conflict analysis triangle

4.3.1 Public values

In paragraph 4.2, ten municipal themes were discussed with regard to the answers given by the interviewees. Not all themes can be associated with public values, for instance, regulation and cycling culture. The topics discussed in the other eight themes contained identified public

values. This was followed by identifying the most mentioned points of interest of municipalities, which provides the degree to which a public value is shared by interviewees.

In table 4 those public values are presented. In the second column, the amount of municipalities mentioning this public value is counted.

As stated in chapter 3, the following definition of public value is used: *"Public values are needs and wishes of inhabitants for the short and long run, pursued by authorities and can be abstract and operational"*

Table 4: Municipal public values

Public value	# mentioned
Mobility	
Flexibility	8
Public transport addition	7
MaaS integration	6
Increase bicycle usage	3
Public space	
Quality of public space	9
Control of public space	8
No commercialization of public space	8
Sustainability	
Air quality	6
Use of active modes	4
Circular economy	2
Sustainable image city	2
Data	
Information	6
Smart cities	3
Privacy	1
Costs	
Public facilities	7
Parking spaces	6
Corporate responsibility	6
Users	
Interoperability	5
Personal responsibility	3
Social inclusion	2
Functionality	
Quality of bicycle	7

Availability	3
Pilot size	3
Stakeholders	
Use by inhabitants	9
Use by commuters	4

4.3.2 Private values and substantiating data

In addition to the interviews with the municipalities, an interview was executed with the owner of Flickbike (Kumanikin, 2017). Also, the committee meeting "Council for the living environment" of the municipality of The Hague was analyzed, in which operators Obike, Mobike and Donkey Republic attended (Gemeente Den Haag, 2017). Based on the interview with Flickbike and public participation by operators in municipal council the interests of the operators were tested with the identified public values. The findings of these activities are processed and combined in table 5 to form conflicts in interests, presented in table 6, which forms the starting points for the design of governance measures in chapter 5.

Table 5: Private values

Private values	Applies to all operators
Make profit	yes
Limit company costs	yes
Maximize the number of users	yes
Maximize the number of bicycles (to their business model)	yes
Maximize freedom to use public space	yes
Use of motorized vehicles for redistribution	yes
Limit openness to competitors and municipality	yes
Commercialization of public space	yes
Collect user data	yes
City-wide implementation of bicycles	Not all (3 of 4 of considered operators)
Open to interoperability	Not all (9 of +/- 11 Dutch operators)

This results in table 6, which consists of times mentioned by municipalities and in the other part if it resulted in a conflict with private interests.

Now both public values and private values are identified they are confronted to check if conflicts arise from these values. In table 6 this step is illustrated and shows which public values are not in line with the values of operators as defined in table 5.

It should be noted that, if a conflict is attributed to a public value, was a fairly subjective call solely based on answers by municipalities and four BSS operators. It is not claimed the priorities and severity of the conflict will be repeatable. But to guide the selection of areas of which design for governance will be conducted, this was merely helpful.

Table 6: Conflicts between public values and private interests

Public value	# mentioned	Provides conflict with private values
Mobility		
Flexibility	8	X
Public transport addition	7	X
MaaS integration	6	
Increase bicycle usage	3	
Public space		
Quality of public space	9	X
Control of public space	8	X
No commercialization of public space	8	X
Sustainability		
Air quality	6	X
Use of active modes	4	
Circular economy	2	X
Sustainable image city	2	
Data		
Information	6	X
Smart cities	3	
Privacy	1	
Costs		
Public facilities	7	X
Parking spaces	6	X
Corporate responsibility	6	X
Users		
Interoperability	5	X*
Personal responsibility	3	X
Social inclusion	2	
Functionality		
Quality of bicycles	7	X
Availability	3	X
Pilot size	3	
Stakeholders		
Use by inhabitants	9	X
Use by commuters	4	

**as mentioned in table 5, nine out of eleven operators signed the intention statement to connect their scheme to an interoperable applicatio*n (Enigma, 2017)

The conflicts are shortly illustrated:

The private value to make a profit and maximize their fleet will lead to flexibility for users to use the bicycles wherever they want with a lot of bicycles in the operating area. But municipalities would like to see the bicycles used in an orderly an structured way, for instance near public transport hubs and designated parking spots. These obligatory parking spots will automatically lead to less flexibility for the user. The value to make BSS an addition to public transport asks for available parking spots near the train station and other public transport hubs, which are currently often no parking zones for bicycles.

The conflict on public space is driven by the operator's values to maximize their fleet, users and profit and use the public space as their point of issue. This leads to conflicts on control, quality and no commercialization of public space as public values.

The current BSS have not proven to improve the air quality in cities, therefore there is scepticism to what extent these bicycles can replace polluting trips by motorized vehicles. Also, the circular economy potential is not met looking at the Chinese BSS examples and no specific sustainable plans are currently expressed by BSS operators.

The data of operators is not automatically open for authorities and therefore cannot automatically be used as mobility information for urban planning or analysis.

The introduction of BSS can lead to extra municipal costs if these costs are not partly or completely covered by the business case of operators this can lead to conflicts with the public. External and unexpected costs should be calculated into the schemes.

Not all operators have signed the interoperability letter of intent, which does not guarantee that an operator is open to sharing technical information with competitors. Authorities value this as crucial to integrate BSS into future MaaS platforms. Personal responsibility versus corporate responsibility illustrates to what extent an operator should feel responsible for the behaviour of the users. This results in the conflict to what extent an operator can be held responsible for misuse of shared bicycles by individual users.

The quality of the bicycles and availability for a wide range of inhabitants is important for the municipalities. The private value to limit costs can result in less qualitative bicycles and operators focussing on specific target groups like young people, students or tourists. These target groups can be less picky about bicycle characteristics. The focus on tourists can provide a conflict with the public value to become a service for inhabitants, rather than tourists.

The conflicts that are taken into consideration for further analysis are the most dominant and will be illustrated in the next paragraph. Based on table 6, a first shortlist of public values considered as dominant is identified If it was mentioned the most and it provided a conflict with private values. This leads to the following list:

1. Public Space: Quality of public space
2. Stakeholders: Use by inhabitants
3. Mobility: Flexibility
4. Public Space: Control of public space
5. Public Space: No commercialization of public space
6. Mobility: Public transport addition
7. Costs municipalities: Public facilities
8. Functionality: Quality of bicycle

A couple of public values are very similar and will, therefore, be merged and considered as one public value. The three public space conflicts will be merged and the mobility values are identified as one value in the next paragraph.

As mentioned in paragraph 2.7, the found conflicts would be substantiated by the Flickbike dataset if possible. This was done to check whether a conflict provides a real conflict based on the Flickbike dataset. This is the substantiate step as defined in the research design.

As identified in the previous analysis, one of the public values was the desire to implement a system that was mainly useful for inhabitants and did not want a BSS that was solely used by tourists, 'stakeholders: use of inhabitants' in the list of values. Since Amsterdam was the operating area of Flickbike, the data analysis could identify the percentage of trips executed by foreign users, which can be interpreted as to what extent the service was adopted by inhabitants in contrast to tourists. This provided the insight that 85% of the total trips were executed by inhabitants. Which leads to the conclusion that the matter of concern that only tourists will make use of the system is no longer valid and will therefore not be used in the design phase. Additional findings of the data analysis like usage patterns at the time of the day and at days of the week, average usage characteristics (duration) and average trip lengths can be found in Appendix I.

Now the substantiation step has been executed this results in the following list of dominant conflicts:

1. Public Space (quality, control & no commercialization)
2. Costs municipalities
3. Quality of bicycle
4. Mobility (public transport addition & flexibility)

4.4 Most dominant conflicts

In this paragraph, the most dominant conflicts are presented to use during the governance design phase in chapter 5. These dominant conflicts are defined by the times the corresponding public values are mentioned as included in table 6. To clarify the problem, 'conflict' and 'municipal objective' are explicitly explained as a starting point for design measures in chapter 5.

4.4.1 Public space (quality, control & no commercialization)

The public space is always the point of issue of the good of the operator. As the size of the fleet increases, the amount of public space that is used increases. An operator does not have an incentive to ensure the quality of public space. If an operator wants to increase the fleet it will not be halted, unless governance intervention is introduced. Without proper governance, responsibility for decreasing quality for the inhabitants and the control over orphaned bicycles remain tasks for the municipality. Alongside the physical occupancy of public space, commercialization of public space is usually not wanted, although this might differ based on political views. The private view on this topic is clear: public space should be available for commercial use.

Conflict

Operators do not automatically care for the quality of public space: they want to have as much as space needed to deliver their service to their customers. Responsibility for the living environment of users and non-users is the core of the conflict.

Disagreement exists on topics like:

- Redistribution: costs and logistics. Who is responsible for bicycles outside the operating area. Municipalities can receive complaints from misplaced bicycles, which they have to remove. This adds to the logistic challenges and corresponding costs.
- Misplaced and broken bicycles. What are the procedures of the operators to control and regulate their fleet. Are there functionalities in the application to report broken or wrongly placed bicycles.
- Ownership: the user or the operator. To what extent is the operator responsible for the behaviour of the user. During a trip the user can be responsible, but should this be defined as short-term ownership of the bicycle by the user, which ends when the bicycle is not used. Enforcement of the municipalities should know who they should address if issues occur.
- Non-users are bothered with their presence if not used or wrongly placed. The irritation with the decreasing quality of public space can directly be attributed to the operator because they are easily identified. This is a major difference with private bicycles.
- Responsibility for and costs of complaints. Should there be a back-office to issue complaints by users and non-users. Should the operators implement this or is this a task for the municipality.
- The utilization rate of bicycles. Should a shared bicycle be used more than a private bicycle. If such a minimum use is introduced, how can this be regulated and controlled?
- Commercialization of public space. Can the bicycles have adds or commercial expressions on their bicycles. If so, is this commercialization of public space?

Municipal objective

Protecting the quality of public space. The pressure on public space caused by the bicycle fleet of operators can be severe. It is important to establish responsibilities and monitor utilization of the fleet.

As can be gathered from figure 12, taken from the initial system overview developed in paragraph 4.1, the use of public space is influenced by some system factors. These factors can be considered to develop governance measures in chapter 5.

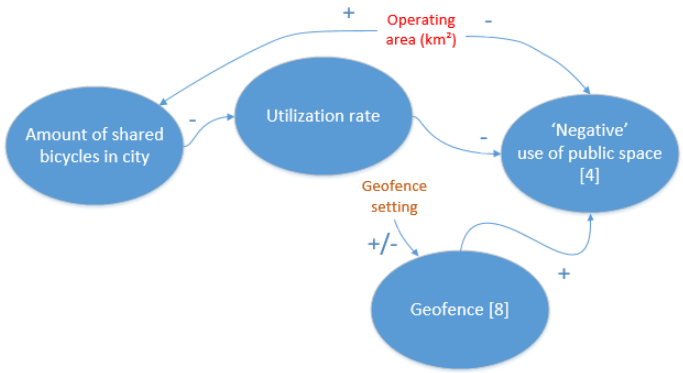

Figure 12: Relation utilization rate and use of public space

4.4.2 Costs municipality

The municipal parking facilities and general cycling infrastructure were used freely by the operators during their introductions in the Netherlands. Some operators did not notify the authorities before they entered the city. This happened because no legislative frameworks required this for dockless operators. The costs for handling wrongly parked bicycles, handling complaints of citizens and pressure on public parking facilities were not regarded as the responsibility of the operator. As the operator's interest is to keep their costs as low as possible, they simply ignored these effects.

Conflict

Upon introduction of a BSS in a city, many effects it has on the pressure on public services are unknown. In practice, these costs are paid by the public. It is important to understand the impact these costs have, and adjust measures accordingly.

Disagreements exist like:

- Creating extra bicycle parking facilities. If extra facilities should be introduced and installed, shouldn't the commercial companies pay for these extra facilities and pressure on enforcement and commercialization of public space.
- Handling costs of removed bicycles. The initial increase of bicycles in the city can increase the pressure on handling wrongly parked bicycles. These costs can be calculated to the operators.

Municipal objective

Distribute costs for running a BSS in a city fairly. Divert costs from the taxpayer to the operator responsible. This asks for identifying costs for items needed for BSS implementation and that also unexpected and indirect costs should be identified.

4.4.3 Quality of bicycles

From the interview with Flickbike was gathered that a miscalculation was made with regards to the necessary quality of the bicycle. There were a lot of malfunctioning bicycles on arrival (7%) and were vandalized during the period of operation (10%) (Kumanikin, 2017). In discussion with the municipalities, this was also mentioned regularly as a point of concern. Also, some municipalities experienced the impact of the inferior quality of these bicycles: broken, rusty bicycles and uncomfortable usage.

Conflict

Operators have a lack of quality requirements for their material. Their private value for maximum revenue conflicts with the public value to have high quality, usable and comfortable bicycles to the Dutch standard.
Disagreements exist like:

- Cycling comfort. The first BSS in Amsterdam and Rotterdam did not meet Dutch standards of bicycle comfort. The high bicycle ownership creates an expectation of what a bicycle should be in terms of comfort. Smaller Chinese bicycles can be a turnoff to use the bicycles as replacement for their personal bicycles.
- Sustainability. The redistribution of bicycles is currently done by motorized vehicles. For the sustainable image it is not desired to use polluting vehicles for redistribution of 'sustainable mobility'.
- Durability. If the bicycles are introduced, this should contribute to the sustainable image of the city and sustainable mobility. If the bicycles are not produced and maintained in a sustainable way, cities are less willing to accept the system.
- Ergonomics. The Dutch user has other desires and wishes in terms of bicycle characteristics than an Asian user. So, operators should create ergonomic suitable bicycles for the Dutch potential user. The first schemes introduced in the Netherlands did not always fulfilled this requirement.

Municipal objective

Make sure the quality matches Dutch comparable bicycles in terms of building quality, comfort and ergonomics, and sustainability. This could mean a standard on quality should be established. Knowledge about this subject might not be present. Legislation and establishment of a quality control institute might be involved.

4.4.4 Mobility (public transport addition & flexibility)

Operators have an incentive to become a mobility option for potential users. They see the surface of the municipality as an operating area and mainly focus on hotspots for potential users. Flexibility in terms of a free-floating fleet is also a big advantage for the operator since they do not have to reserve and create specific parking spaces. Also, they can offer this flexibility as a benefit of their offered service to the user. But, the operators are not mainly focused on becoming an addition to the existing public transport system. Rather they will become a part of mobility as large as possible to maximize revenue. Therefore, the public value of becoming an addition to public transport is partially conflicting with private values.

Conflict

The municipality would like to see an expansion of the mobility options and connect with existing public transport, whereas the operator does simply care about the functioning within their system.

Disagreements exist like:

- Replacement of transport use versus an addition to the current mobility options. It is uncertain how BSS should fit into the current mobility system. Should shared bicycles replace trips by car, taxi or only function as a feeder for public transport. But to what extent should the municipality benefit operators by facilitating parking spots near public transport hubs. But, this could be necessary to become an addition to public transport and be an alternative for the PT-bicycle of the Dutch Railways.
- Protection of public space conflicts with the demand of BSS near hubs. The public space around train stations are currently often no-parking zones and underground parking facilities at train stations are affecting the GPS-technology in the bicycles negatively.

Municipal objective

Make BSS an optimal addition to other modes of transport. BSS should be available at the place and moment where they add value. The flexibility of the system should be in line with the first conflict, quality of public space. These values can conflict with each other.

5 Design

This chapter will present governance measures to cope with the identified conflicts presented in chapter 4. Firstly the design approach will be presented and thereafter the conflicts with suitable measures are presented. Paragraph 5.3 will give an overview of the measures and potentially other institutions or levels of governments that can be involved.

5.1 Design Approach

The design of measures was based on the design triangle presented in figure 13. The three sources are used to introduce measures to cope with the found conflicts, the source on which the measure is based on will be included.

The design triangle consists of

- Literature, for example, international examples of measures that were successful and implemented in foreign BSS. In addition, semi-scientific articles can be an inspiration for these measures;
- Model, the initial model that was presented in paragraph 4.1 identified causal relations and can, therefore, be a source for suitable measures;
- Interviews, during the interviews with municipal experts multiple ideas and examples were suggested and drawn into attention. Therefore these could also be used in the design process.

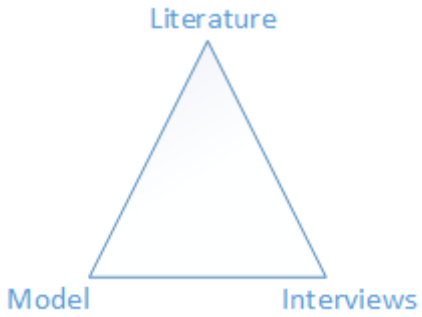

Figure 13: Design triangle

5.2 Conflict and measures

As described in chapter 4 there are four conflicts used for this design chapter. *Public space (quality, control & no commercialization)*, *costs for the municipality*, *quality of bicycles* and *mobility (Public transportation & flexibility)*. In the following paragraphs, the measures are explained and linked to the design triangle.

5.2.1 Public space (quality, control & no commercialization)

Measures

Determine minimal usage of a bicycle per day. The actual required minimal usage per day will differ per municipality. Every municipality has different characteristics that influence the possible and desirable utilization rate: surface area, target groups (commuters, tourists or inhabitants), population density, other transport options etc. This calls for a pilot project, careful monitoring and respecting a start-up period for the system.

As defined in the initial system overview in paragraph 4.1 this minimal usage per day can be monitored using a utilization rate defined by shared bicycles in use divided by the total amount of shared bicycles in the city. Also, the total trips on one day can be divided by the total bicycles in the operating zone, which result in an indicator as used by E. Fishman, Washington, Haworth, & Mazzei (2014) defined as trips/bike/day. This average of trips per bike per day is commonly used in foreign evaluation studies of bicycle sharing pilots.

Restrain commercialization through legislation. Legislation for instance concerning the possibility to use the bicycle as an advertising mechanism and allowing public space to be used for commercialization through issuing permits. The latter is done in Seattle, as can be seen in Appendix D. They use a permit system per bicycle and an operator license. The degree to which the public space is commercialized can be done by adjusting these measures to the present political context.

Require accelerometer in the bicycle to identify fallen bicycles. Fallen bicycles present a great nuisance to the public. The operator should adapt their redistribution plan giving priority to resolving the fallen bicycles. (Arno, Toyoda, & Sasase, 2016) presented an accelerometer assisted smart lock for bicycle sharing in their paper to support BSS operators in their identification of fallen bicycles and general trip authentication challenges. Requiring these accelerometers can, therefore, contribute to a better public space if fallen bicycles are taken into account in the redistribution scheme of the operators.

Introduce a Universal logo for bicycle sharing. Improving communication about new initiatives to develop understanding and recognisability of allowed bicycle sharing. Dedicated parking spots can be marked by using a universal logo of the modality of shared bicycles. A similar initiative is developed for car sharing, a logo is designed for bicycle sharing as can be seen in Appendix K. This carsharing logo is developed by Platform Autodelen (2018) and is adopted among multiple Dutch municipalities and is also used in European cities like Bergen and Bremen. This logo can also be used for interoperable systems as stimulated by the national government (Enigma, 2017). Introducing such a logo can be a task for CROW or another independent organisation to ensure that not one operator is favoured.

Require good behaviour incentives. The responsibility of the user for the bicycle in the case of BSS ends at the moment a trip ends. This may cause lax behaviour, misplaced and vandalised bikes. To encourage the user to exhibit good behaviour, they can be awarded points or penalties. Mobike has implemented a system like this, as can be seen in Appendix E.

Enforce geofences. This geofence is an allowed operating area that is virtually demarcated using GPS (Gemeente Rotterdam, 2018). A number of locations can be assigned by a municipality that BSS operators can use as 'point of issue'. If geofence technology is improved and it becomes impossible to lock a bicycle outside of a dedicated geofenced zone, users can be forced by this measure to use the system in an orderly manner. Although this measure reduces flexibility in mobility, it can secure the quality of public space in a city. By implementing geofence technology bicycles are concentrated at assigned municipal locations instead of 'floating' in a city. This enforcement of geofence technology can be part of a permit or tender.

Create incentives to have bicycles moving. Moving bicycles have little effect on public space. This also adds legitimacy to the presence of the BSS in a city: if they're in use, they are wanted. So the use of bicycles per day should be easily and continuously monitored. The municipality should have insight into this measure and take action if necessary. Operators can be forced to come up with incentives to increase the average use of bicycles by introducing discounts or use gamification in operating schemes (Hamari & Ukkonen, 2016).

Require communication channel for *all* complaints. BSS operators must be aware of all users of public space. Non-users should easily be able to leave their remarks about the system, so operators should be accessible through email and phone. This can be part of an SLA, a service level agreement or a concession. Such a communication channel for all stakeholders is also required in the Seattle BSS (Appendix D).

Ensure even spread of the bicycles. It is considered annoying to have a lot of shared bicycles on a small surface area. So distribution should take care of an even spread of bicycles and not occupy an entire rack. Enforcement of this is tricky and at least very laborious. Nevertheless, this would contribute to a better quality of public space. In a study of Caggiani, Ottomanelli, Camporeale, & Binetti (2017) they developed a spatiotemporal forecasting method to secure an even spread of free-floating bicycles. So this should be possible to implement in a scheme.

Require openness in trip data. Operators are not too keen on giving access to their usage data at the moment. The use of public space by the BSS is legitimized by the public value being added. To secure the quality of the public space, the use must be monitored. Furthermore, because the operator commercializes the public space, the municipality has the right to have access to the data gathered there. The requirement to share data could, for instance, be included in a permit or SLA for an operator. This openness of trip data is also suggested as important by two experts in BSS, Luud Schimmelpenninck and Ronald Haverman (De Correspondent, 2017).

Furthermore, municipalities stated, during the interviews, that trip data might be interesting for municipal use for the design of infrastructure. Operators have indicated they expect municipalities to pay for the data.

Evaluating the performance of measures

Some measures are entry-requirements, so they have to be checked on introduction. Other require continuous monitoring. It is recommended to have periodic evaluations with the

operator where they present a concrete and data-driven analysis of the established performance metrics. In which phase a measure should be introduced or considered is included in the overview in table 7.

5.2.2 Costs for the municipality

Measures

Arrange parking facilities for the period the number of bicycles in the city is higher. If the number of shared bicycles is high, this causes high pressure on existing parking facilities. It is expected that at least during the adoption period of the BSS, the number of bicycles will increase, but will decrease when the private bicycle ownership decreases (Bachand-Marleau, Lee, & El-Geneidy, 2012). Yet there is no proof of this actually happening, in foreign and Dutch research. Costs arising for these facilities should be paid by the operators, was an often heard comment during the interviews. In addition, this was mentioned as a possible requirement for operators in the report of the Institute for Sensible Transport (2016), which researched the possibilities for Adelaide and Melbourne. The costs for these extra parking facilities could be calculated or required from the operators with a permit or are allowed.

Make handling wrongly parked bicycles at least break even. At the moment, the costs to remove and store a bicycle supersede the earnings of retrieval. This should be matched to not have taxes to cover these costs. This measure can be in a form of a levy, as mentioned during an interview.

Evaluating the performance of measures

Regularly should be evaluated how much it costs the municipality to run the BSS in the city. Together with the operator, these costs should be discussed. The costs for facilities should be part of a contract with the permitted operators in advance of the operation.

5.2.3 Quality of the bicycles

Measures

Establish quality standards and assessments before introduction. This could best be established in national policy. An institution like CROW Fietsberaad should be appointed to formulate a pack of requirements or a kind of certification of quality. By addressing this nationally, municipal transaction costs can be diminished. If an operator is approved, a local government can easily choose between operators. The assessment of quality is also identified by Campbell, Cherry, Ryerson, & Yang (2016) as an important factor to influence the choice for an operator by users.

Ensure sustainability of the produced bicycles. Operators should provide a corporate responsibility report in terms of sustainability. Environmental footprint, durability and maintenance efforts should be part of their company policy and reflect on their efforts. This evaluation of an operator is best executed on a national level as well and can be part of the certification of quality. This sustainability issue was mentioned during an interview.

Monitor quality performance during use. To ensure the quality in the long run, periodically the bicycles should be checked if they still comply with standards. This is best done nationally

as well, as the certification is issued at that level and can be revoked as well. The Seattle authorities do this also periodically to ensure quality standards of the bicycles, also for safety and insurance reasons.

Evaluating the performance of measures

Operators should be exposed every year to a monitoring quality check, which would allow them to operate in the whole of the Netherlands. Also, if they are about to introduce a new model of bicycles, these should be approved by the authority as well.

5.2.4 Mobility (Public transport addition & flexibility)

Measures

Allocate space for BSS near mobility hubs. At the moment, parking shared bicycles near railway stations is often prohibited. This counteracts the public value to have BSS add options to the public transport offer. It is recommended to allocate dedicated space to BSS near hubs. This can be arranged in the spatial planning of a PT hub. Kager, Bertolini, & Te Brömmelstroet (2016) also mentioned well-integrated mobility systems to improve cycling-transit integrations. Hubs near public transport for shared bicycles can contribute to this integration of modes.

Force integration of BSS with PT offer by making it part of a concession. Provinces are entrusted with the grant of a concession of public transport in a region. Currently, they are exploring the option to integrate shared bicycles into the concession. This way, the concessionaire must incorporate a BSS in their tender. In this concession must be included how BSS is incorporated in the mobility chain. Kager & Harms (2017) suggested adopting both cycling, public transport and other modes in one concession to improve the synergy between different modes in the mobility offering.

A point of attention is the endorsement of the BSS by the concessionaire. The balance in the mobility offer must be readjusted under influence of BSS. It is advisable to be watchful on the intentions of the public transport provider coping with this innovation as it is a more traditional institution.

Through the concession, the PT provider is charged with the selection procedure of a BSS, so a lot of preparation work can be delegated. This saves time for the municipality and so diminishing transaction costs for implementation.

Evaluating the performance of measures

Spatial use in the vicinity of PT hubs must be monitored. This is the responsibility of the municipality. If the nuisance or pollution of the living environment gets too severe, action should be taken. In the concession process, an SLA will be composed where the performance of the whole mobility chain should be secured. Part of this should be BSS usage metrics.

5.2.5 Conclusion on coping measures

These applicable coping measures are available for municipalities or can be used by a higher level of government, for instance, to reduce transaction costs for individual cities. Based on the

political point of view dominant in a city, a set of measures can be allocated to withstand disruptive elements of dockless BSS. It is up to policymakers to decide what measures are most suitable for their municipality.

5.3 Overview

The previous paragraph outlined multiple coping measures that can contribute to overcoming the conflicts between public and private stakeholders. These findings give an answer to the third subquestion of this research: What measures can Dutch municipalities take to cope with these conflicts?

5.3.1 Table of measures

In table 7 an overview is presented of proposed measures in paragraph 5.2. In addition, the moment this measure should be thought of and implemented is included in this table. As can be seen, these moments are identified as *in advance, during and periodically.*

Table 7: Overview of coping measures

	Measure	In advance	During	Periodically	Source
Conflict 1	Determine minimal usage of a bicycle per day*	X			Initial Model
	Restrain commercialization through legislation	X			Seattle permit scheme
	Require accelerometer in the bicycle to identify fallen bicycles	X			(Arno, Toyoda, & Sasase, 2016)
	Introduce a Universal logo for bicycle sharing*	X			Autodelen.net
	Require good behaviour incentives	X	X		Mobike
	Enforce geofences	X	X		Gemeente Rotterdam and others
	Create incentives to have bicycles moving		X		(Hamari & Ukkonen, 2016)
	Require communication channel for *all* complaints		X		Seattle permit scheme
	Ensure even spread of the bicycles		X	X	(Caggiani et al., 2017)
	Require openness in trip data*	X		X	Model / (Haverman & Schimmelpennink, 2017)
Conflict 2	Arrange parking facilities	X	X		Institute for Sensible transport (2016) / Interviews
	Make handling wrongly parked bicycles at least break even		X		Interviews
Conflict 3	Establish quality standards and assessments before introduction*	X			(Campbell et al., 2016)
	Ensure sustainability of the produced bicycles*	X			Interviews
	Monitor quality performance during use*		X	X	Seattle permit scheme
Conflict 4	Allocate space for BSS near mobility hubs	X			Interview / (Kager, Bertolini, & Te Brömmelstroet, 2016)
	Force integration of BSS with PT offer by making it part of a concession	X			Interview/ (Kager & Harms, 2017)

5.3.2 Higher levels of government

As can be seen in table 7, some coping measures are indicated with an asterisk. These measures are identified as suitable measures to potentially be taken care of by policy of higher levels of government. For reasons of efficiency and effectivity, municipalities or provinces can also work together to cope with specific issues. Brabant5 (2018) for instance, cooperation between 's-Hertogenbosch, Eindhoven, Tilburg, Breda and Helmond, bundled their forces to tackles issues concerning BSS. They have regular meetings on the future of bicycle sharing in their cities and share best practices with their partners. This could be a form for other provinces as well to encourage within their operating area.

An official institution like CROW and is a non-profit, can also be very relevant in sharing knowledge among municipalities and provide knowledge papers about coping with BSS. This would limit costs for individual municipalities and is, therefore, more efficient.

6 Conclusions and discussion

This research was directed to answer the following question:

How can Dutch municipalities cope with the disruptive innovation of dockless bicycle sharing in order to resolve the conflicts between public and private values?

The experiences in Amsterdam, Rotterdam and cities all over the world with dockless BSS caused a lot of unrest among citizens. The market of BSS has proven not to regulate themselves and the operators experienced intense competition. This lead to an extreme expansion of bicycle fleets, limited communication with authorities and high pressure on public space. The innovation of payment options, GPS-technology and QR-codes enabled the BSS-operators to introduce dockless bicycle sharing. This dockless bicycle sharing has two appearances: free-floating and geofenced systems. Both have increased flexibility for the users but have also more characteristics to create disorder and chaos, since users can park the bicycles everywhere.

This made it necessary to identify and prioritize public values. Since these public values provide a good starting point to explore the particular municipal needs and wishes. If goals are defined for the particular municipality proactively, so before operators are introduced, this can be helpful. Integration in public transport policymaking in terms of adding to the offer already present is wisely. Postulate conditions for the addition to the mobility market.

Municipalities have three ways to regulate the market in general: prohibit/enforce, pricing and soft regulation. These should be used wisely and appropriately to the identified conflicts. The coping measures per found conflict are presented in addition to the conflict with private values:

Private values do not automatically preserve the quality of public space, the drivers to maximize the number of bicycles and users to increase the company profit conflicts with the following public value.

Public space (Quality, control & no commercialization): Determine minimal usage of a bicycle per day, Restrain commercialization of public space through legislation, Require accelerometers in the bicycles to identify fallen bicycles, Introduce a Universal logo for bicycle sharing, Require good behaviour incentives, Enforce geofences, Create incentives to have bicycles moving, Require a communication channel for all complaints, Ensure even spread of the bicycles and Require openness in trip data.

External costs induced by the introduction of BSS are not covered by the operators. The facilities are used freely and enforcement of wrongly parked bicycles is also done by municipal workers. The costs are a point of concern for the authorities:

Costs for the municipality: Arrange parking facilities for the period of time the number of bicycles in the city is higher, these costs for extra facilities can be calculated in permit fees or with other forms of contracts. In addition, make handling wrongly parked bicycles at least break even. This means that costs for removing wrongly parked bicycles should be paid by the operators.

The first systems introduced did not meet the standards of Dutch bicycles and the quality was therefore not sufficient. Broken and orphaned bicycles were not taken care of by the operators, which was a factor for the negative image of BSS in general.

Quality of the bicycles: Establish quality standards and assessments before introduction, Ensure sustainability of the produced bicycles and monitor the quality performance during use.

The introduction of BSS is not automatically introduced in relation to public transport. In addition, train stations are often limited in parking space or have no parking zones for bicycles, therefore operators cannot use this space as a point of issue. The schemes should add value in addition to the current mobility system. It should provide *flexibility* for the user, but also be useful in relation to public transport. Although operators want to offer flexibility to their users, current general local regulations can impede the functionalities of the systems.

Mobility (Public transport addition & flexibility): Allocate space for BSS near mobility hubs, for instance near public transport locations. Force integration of BSS with PT offer by making it part of a concession.

The analysis of public values in relation to private values in order to find conflicts that have to be tackled during the introduction of BSS provides a good analysis tool for research like this. This can provide insights into the contribution to the mobility system in urban environments and possibly contribute to an alternative that can be offered to the personal mobility currently available.

The findings of this research are generalizable in the Dutch context. Dutch municipalities were interviewed for this study, these were of different size and from different regions. During interviews, a lot of similar issues were addressed by the interviewees, which lead to the saturation of answers. Besides Dutch municipalities, foreign cities can benefit from the insights if similar public values conflict with private values.

Higher levels of government could play a role for reasons of efficiency and effectivity. If cooperation between cities is encouraged by provinces or institutions like CROW, best practices and regulation strategies can be introduced more effectively.

Discussion

In order to explore the coping mechanisms for municipalities, public values were established from the requirements and desires of municipalities. Next, these were set against private values that were uncovered from the interviews and hearings of operators. Together with trip data analysis, these provided conflicts. The most prominent conflicts were extracted and formed the input for the design of coping measures for municipalities. This research design is considered valuable as input for further research and exploring the coping mechanisms of municipalities in the relatively new field of dockless BSS.

It must be noted that there were constraints in terms of time and resources. For example, the number of municipalities that could be interviewed and the limited data of operators available for research. Then again, in a scientific study of a Dutch context, it is unique and unprecedented that dockless BSS trip data was included. Trip data analysis should be a subject for future research.

The research defined public values raised from the selected municipalities, but it is difficult to be certain that the identified public values can be generalized for all Dutch municipalities. For instance, the various levels of urbanity of the interviewed cities may have influenced the used conflicts for design. It can very well be that for different municipalities other conflicts have more priority and ask for different, new measures.

Civil servants and policymakers can use the identified public values as a guideline to cope with BSS in their specific context. Since coping with friction between these public values and private interests are of major importance to maximize the added value of innovation like BSS and minimize the negative impact it has on society.

Experiences in Amsterdam and Rotterdam have shown the possible disruptive impact of dockless BSS. This indicates one cannot leave the working of a BSS solely in the hands of the free market. The examples of that causing a lot of problems regularly pop up in media.

This study introduced possible measures to cope with the disruptive elements but does not guarantee the successful outcome of these interventions. This is a subject that must be studied after measures are adopted and cities have more experience with dockless BSS.

In addition, it was not the objective of this research to guarantee the success of implementation of a BSS, but rather to provide conditions to implement BSS more successfully.

Recommendations

The phenomenon of dockless bicycle sharing will not disappear in the coming years. Governance strategies will be implemented to cope with future developments in the world of BSS. Several topics within this domain require further examination, some pressing issues are shortly presented and justified below:

Since the first governance measures are being implemented in the Netherlands at the moment, this calls for an examination of the effectiveness. This research merely explored possibilities, but the effectiveness, practical implementation and cooperation on these subjects with operators are still very much unknown.

Only shortly discussed in this research, provinces should investigate the integration of BSS in public transport concessions. How PT companies might integrate this new player on the mobility market is expected to be challenging and disruptive in the sense of interfering with 'regular business' of the PT provider.

Further research should be conducted on gaining better insight into usability patterns. This would lead to a better understanding of public value in terms of mobility. Openness in data of operations would be required.

There are many unclarities about the business models of big foreign bicycle sharing companies. This knowledge is necessary to be able to judge if the private interests align with public values.

General recommendations

Advier should contribute to sharing knowledge between Share North partners about the experiences concerning cooperation with operators and the functioning of the BSS. This will be very helpful to identify differences in public values and resulting conflicts of interests between countries.

Openness in anonymized trip data. This enables a fair evaluation of operators and BSS in general, and might reveal more patterns in usability and can influence design decisions of the system.

The learnings of this research can easily be adapted to help policymakers get started with orienting on BSS. This thesis can be transformed into a more actionable handbook for policymakers.

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Appendix A: Municipal objective tree

In figure 14 an initial municipal objective tree was visualized. In order to get an understanding of the different mode options and sustainable objectives of a municipality might have. The highest level of the objective tree is *welfare*. Which can be set out into *less use of space by modes of transport, more sustainable mobility, better liveability and better accessibility*. These higher objectives are operationalized in the objective tree below.

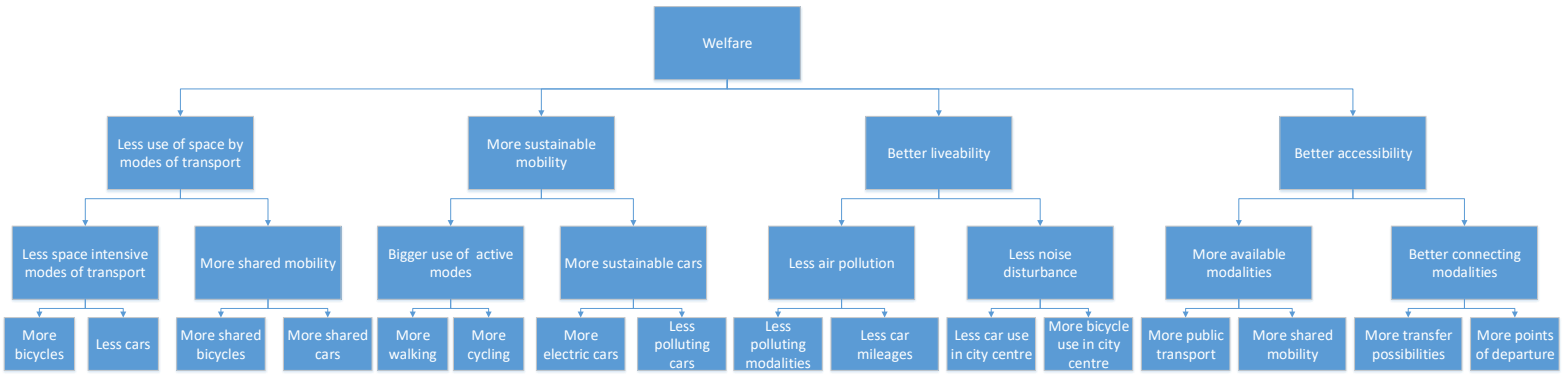

Figure 14: General municipal objective tree concerning sustainable mobility

Appendix B: Prior Literature themes

An initial analysis was executed to identify the common research themes in the field of BSS. There were made general overviews of the history and scale of BSS worldwide, especially the defined 'generations'. Rebalancing and trip data analysis are also common. Some articles addressed the health effects and safety issues, which are topics for countries with limited bicycle culture and limited bicycle mode share. An overview of topics can be found in table 8.

Table 8: Overview of prior literature themes

Subject	Author /year
Bicycle sharing	
General overviews	(Demaio & Gifford, 2004) (Shaheen et al., 2010) (Vogel, Greiser, & Christian, 2011) (Midgley, 2011) (E. Fishman, Washington, & Haworth, 2013) (Matrai & Toth, 2016) (E. Fishman, 2016)
Dockless bicycle sharing	(Pal & Zhang, 2017)
Success determinants	(Médard et al., 2017)
Added value	(El-Geneidy, van Lierop, & Wasfi, 2016) (Bullock et al., 2016)
Health effects	(Woodcock, Tainio, Cheshire, O'Brien, & Goodman, 2014)
Implementation	(Büttner, Mlasowsky, & Birkholz, 2011) (Elliot Fishman et al., 2012)
Trip data	(O'Brien et al., 2014) (Zhang et al., 2017)
Rebalancing	(Raviv & Kolka, 2013) (Pfrommer et al., 2014) (Singla et al., 2015) (Reiss & Bogenberger, 2015) (Reiss & Bogenberger, 2016) (Reiss, 2017) (Pal & Zhang, 2017) (Caggiani et al., 2017)
Medium sized city BSS	(Caulfield, O'Mahony, Brazil, & Weldon, 2017)
Safety	(E. Fishman & Schepers, 2016)
Case studies	(Bachand-Marleau et al., 2012) (Garcia-gutierrez, Romero-torres, & Gaytan-iniestra, 2014) (Elliot Fishman, Washington, Haworth, & Watson, 2015) (Faghih-imani & Eluru, 2015) (Murphy & Usher, 2015) (Campbell et al., 2016) (Nikitas, Wallgren, & Rexfelt, 2016) (Jiménez, Nogal, Caulfield, & Pilla, 2016) (Bejarano, Ceballos, & Maya, 2017)

Appendix C: Spatial impact different modes of transport

In figure 15 the dimensions of the different modes of transport are presented. The dimensions of a BSS with docking stations is also included to take into account what this kind of infrastructure would need in public space. Because the impact is defined by its stationary status, the dimensions of a parking spot are presented in table 9 below.

Table 9: Dimensions of modes of transport

Mode	Width (metres)	Length (metres)	Use of square metres (m²)
Car	2,5	6	15
Bicycle with docking station	0,9	2,5	2,25
Bicycle (free-floating)	0,6	2	1,2
Scooter	1,2	2,5	3

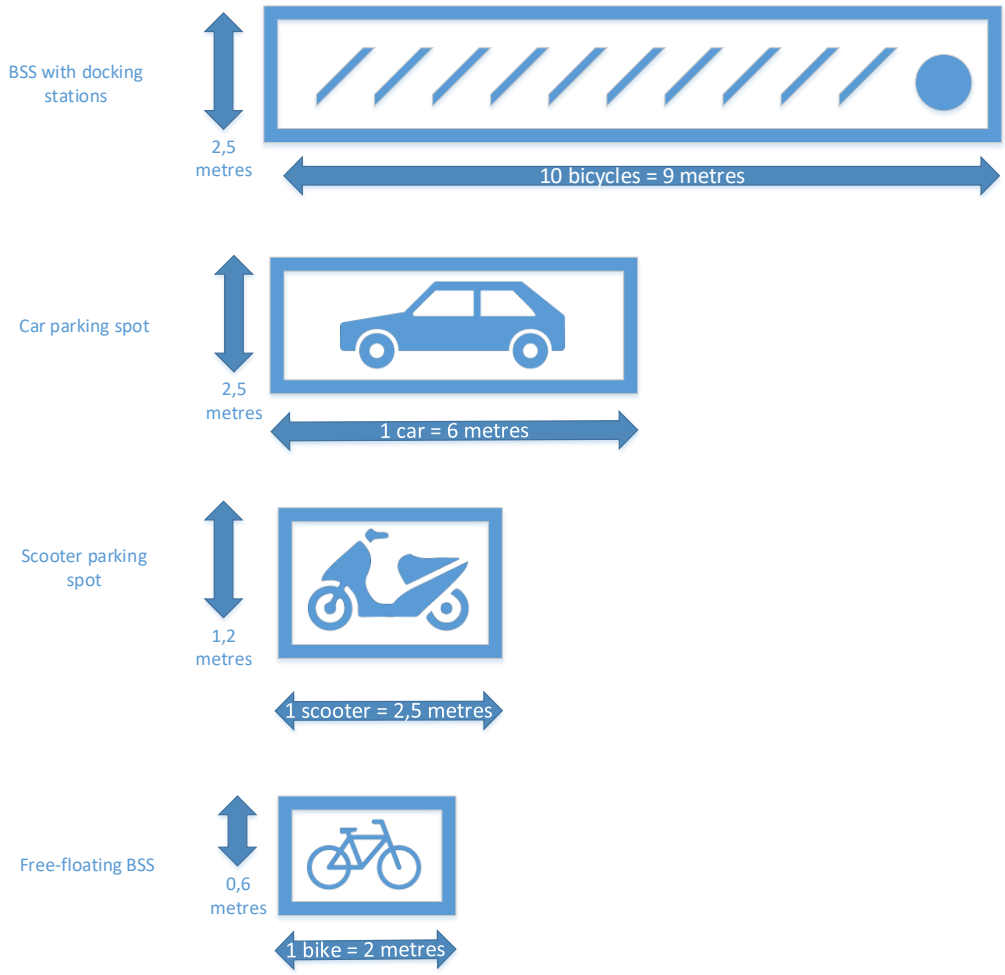

Figure 15: Dimensions of modes of transport

Because municipalities are interested in how authorities can cope with the dockless bicycles in a city it is important to understand what the current spatial impact of the modes of transport is. Policymakers can get an idea about the impact of cars, bicycles and shared bicycles when looking at the case of Amsterdam. In table 10 the amount of the corresponding mode is shown and the space that is occupied if a mode is stationary, therefore a parking spot is used as the spatial impact on a city. The planned amount of shared bicycle in Amsterdam is based on the planning of the municipality of Amsterdam (Gemeente Amsterdam, 2017).

Table 10: Modes of transport in Amsterdam

Mode	Amount	Space/mode	Total impact
Cars in Amsterdam	231.185	15m²	3.467.775 m²
Bicycles in Amsterdam	837.000	1,2m²	1.004.400 m²
Shared bicycles (2019)	9000	1,2m²	10.800 m²
Shared bicycles (summer 2017)	3000	1,2m²	3.600 m²

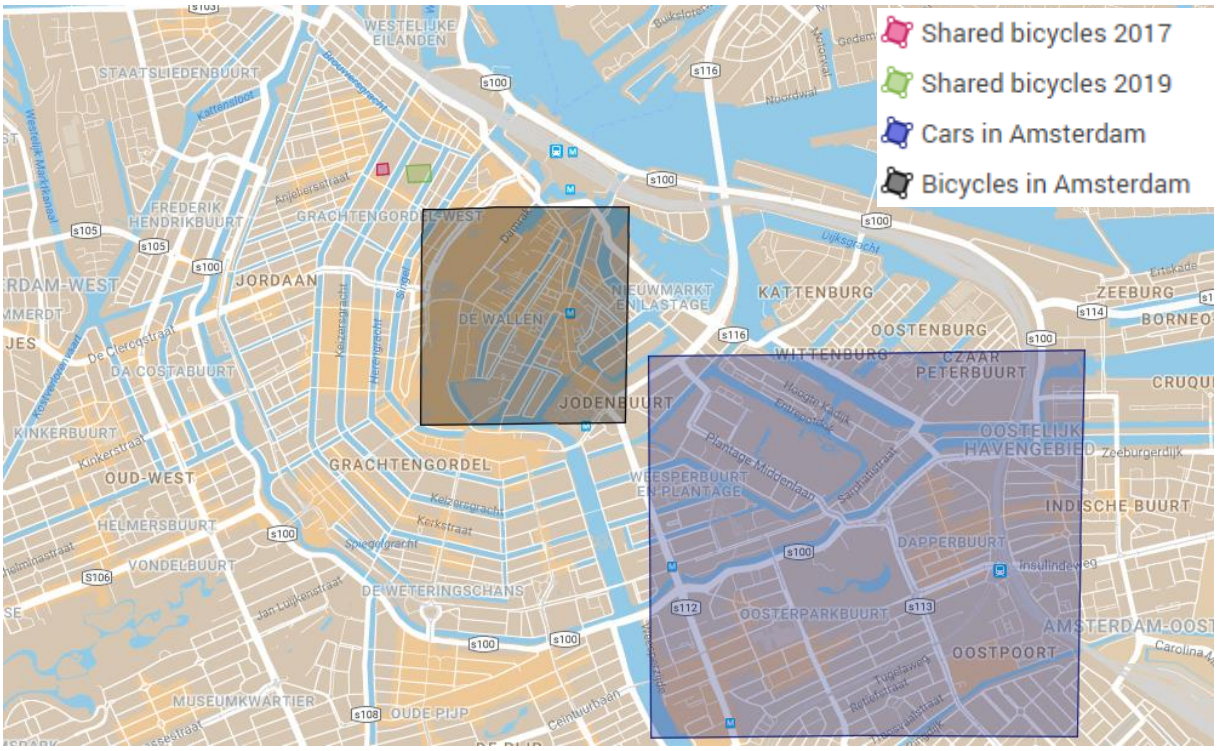

Figure 16: Spatial impact visualization of modes in Amsterdam

Appendix D: Rules and regulations for dockless BSS permits in Seattle

In 2017 the Seattle department of transportation introduced and implemented a bicycle share permit system. In which BSS operators had to fulfil the requirements set by the municipality and were allowed to operate in the city if they would conform to these rules. The Seattle requirements consisted of Safety, Parking, Business Operations and Data sharing elements. In addition, the operators had to pay fees per bicycle and admission during the start of the program, this to cover the operational costs made by the municipality.

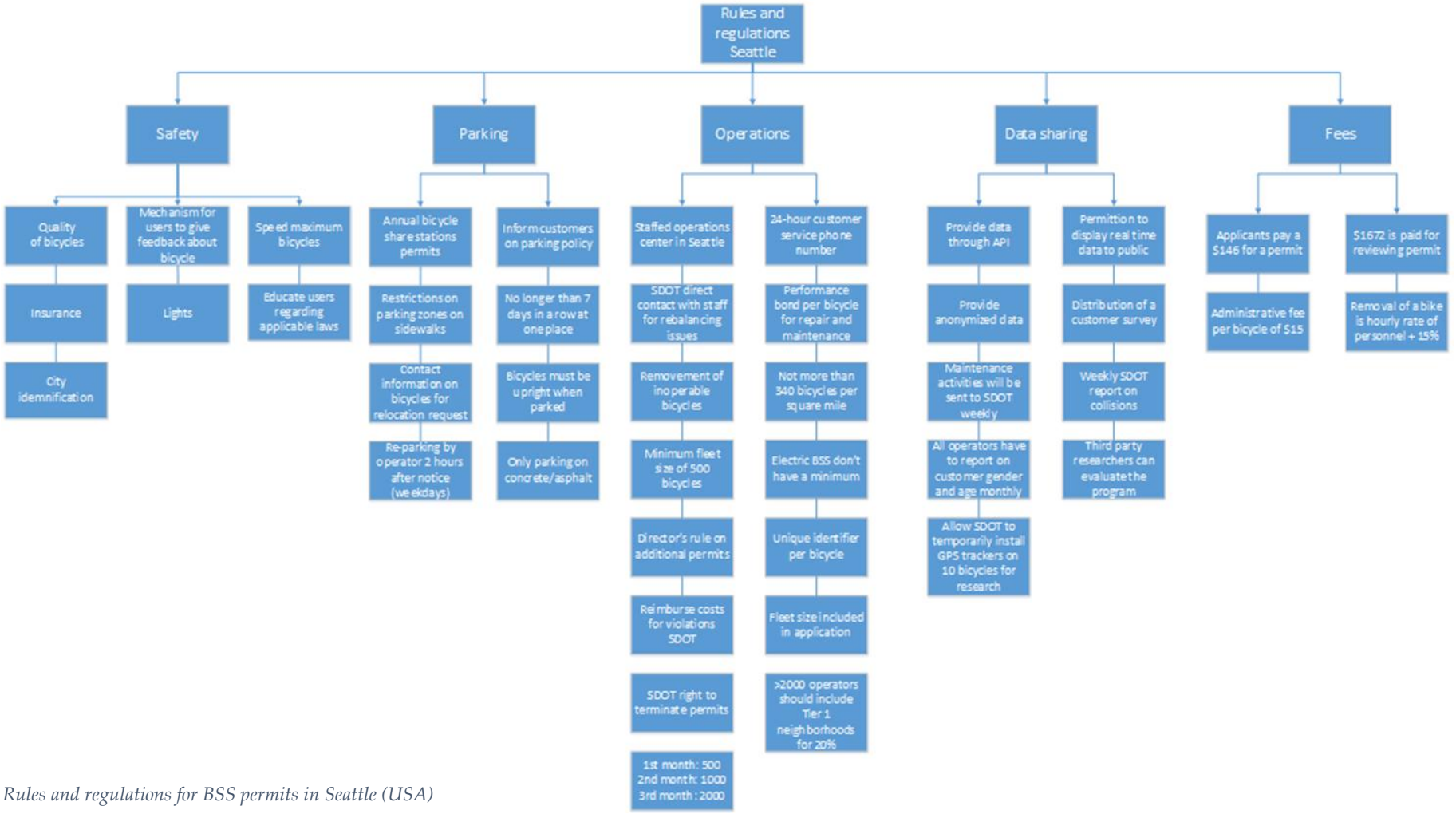

Figure 17: Rules and regulations for BSS permits in Seattle (USA)

Appendix E: Mobike behavioural credit system

Experiences in the past indicated that users or at least the fleet of bicycles do not always show the desired behaviour. The effect of usage and the redistribution effort both influence the positioning of the fleet. Therefore the operators constantly adjust their operations and make usage forecasting to get a better grip on the fleet. Operators are also trying to steer behaviour, or so-called nudging, which is also included in the model in Appendix F.

Mobike has implemented a scoring system to handle and evaluate the behaviour of its users (Mobike, 2018). This is a measure introduced by Mobike to get a better grip on the behaviour of their users. The score does increase due to good behaviour and decreases for bad behaviour. Below are the rules for punishing and rewarding.

Score increase

1. Follow the traffic rules, cycle safely and decently
2. Park bicycles at places that are allowed, so other users can find it
3. Don't misuse the bicycles and keep them clean
4. Support the platform by regularly using the bicycles

Score decrease

1. Unsafe cycling and ignoring traffic rules
2. Parking of the bicycle in a place that is not publicly accessible, such as in the home or garden, cellar or where the parking of bicycles is prohibited
3. Bother other people
4. Damage your bike or lock your bike with your own lock
5. Other violations while you use the bike

Possibilities for users to object

1. You have a lower score because points were deducted due to negative behaviour in the past month
2. You can lodge an objection against the deduction of points via the application
3. After filing a complaint, status can be checked in the feedback portal in the application

Appendix F: Causal system overview

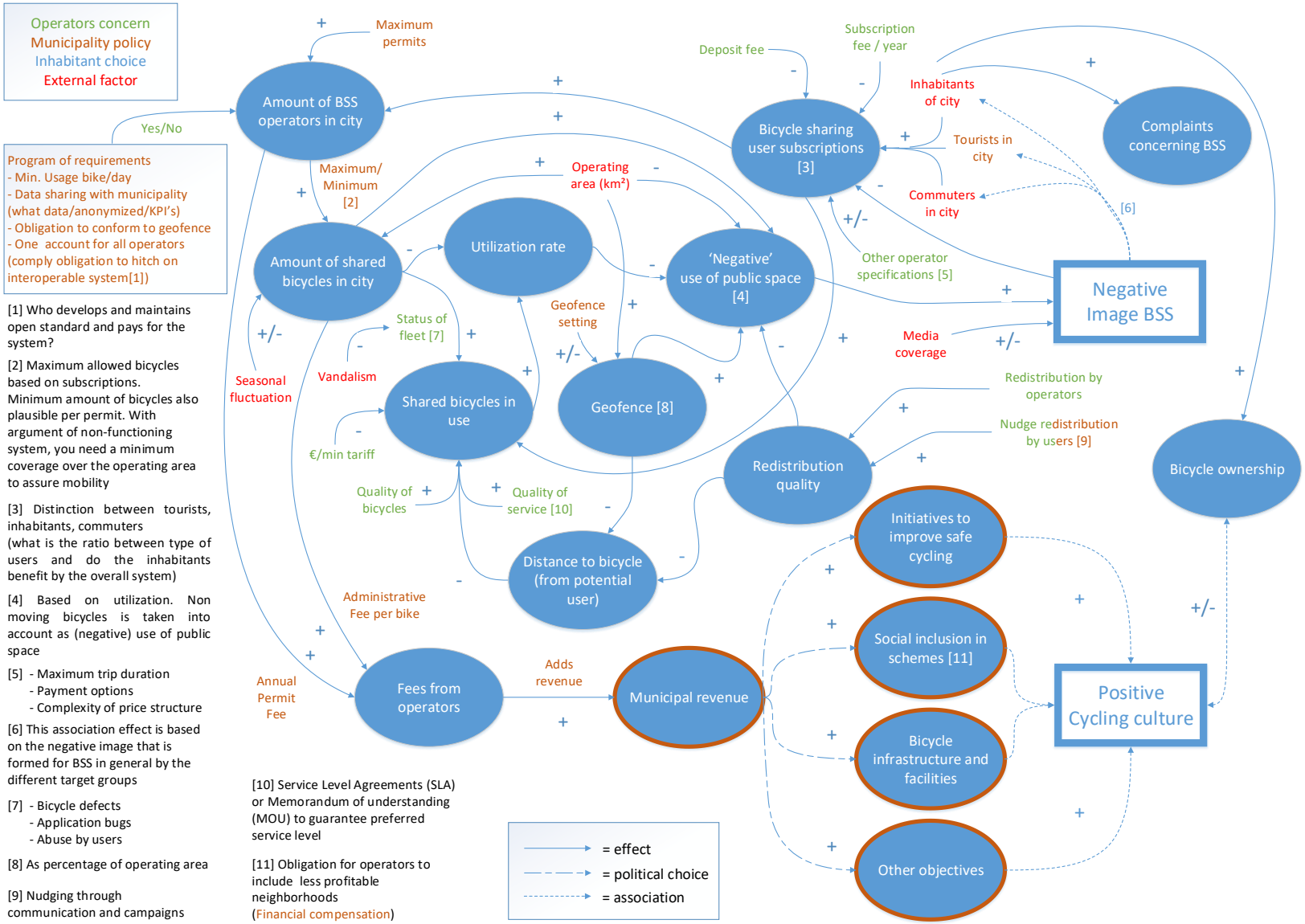

Figure 18: Initial system analysis with notes

Figure 18 is a comprehensive version of figure 10. On the left, the numbers in square brackets are more fully explained. The so-called program of requirements in the model is based on the suggestions of Haverman & Schimmelpennink in De Correspondent (2017). Also, the notations on the left give some extra detail to certain factors, like 'status of the fleet' and 'other operator specifications'.

In the following section, all elements and factors of the model are explained and specified where possible. Some texts are also included in the main report for clarification reasons. In this overview all the related factors ars specified and stakeholders that can influence the factor as well.

- **Amount of BSS operators in the city**

  A municipality should think about the number of operators that is desirable in a city, more operators are good for competition on service and quality of the bikes and differentiation in the type of bicycles is good for potential users and specific user characteristics. English operators are claiming 2 operators is a maximum for a city with less than 150.000 inhabitants (Bikeplus, 2018).

Factor	Influence	Stakeholder with influence
Maximum permits	Positive (+)	Municipality
Program of requirements (Permit system)	Yes/No	Municipality
Bicycle sharing user subscriptions	Positive (+)	Operator (Municipality if subscriptions and amount of bicycles are linked)

- **Amount of shared bicycles in the city**

  The amount of shared bicycles is important to consider because of the impact it has on the public space and the number of bicycles that is needed for the people to improve their mobility and accessibility to the closest shared bicycle (ITDP, 2013). The municipality could monitor the fleet size and the performance of the system in terms of utilization rate to reach a combined optimal fleet size (fleet of the permitted operators combined).

Factor	Influence	Stakeholder with influence
Amount of BSS operators in the city	Positive (+)	Municipality
Operating Area (km^2)	Positive (+)	External
Seasonal fluctuation	Positive/Negative (+/-)	External

- **Shared bicycles in use**

  The number of bicycles that are used on a regular basis. This is fluctuating over time and should, therefore, be evaluated with that in mind (Zhang et al., 2017). Also,

weather and seasonal factors should be studied to review performance. But can also influence the number of bicycles in the city during a certain season (O'Brien et al., 2014).

Factor	Influence	Stakeholder with influence
€/min tariff	Negative (-)	BSS Operator
Quality of bicycles	Positive (+)	BSS Operator
Distance to bicycle (from potential user)	Negative (-)	Operator(s)/Municipality
Amount of shared bicycles in a city	Status of fleet	BSS Operator
Bicycle sharing user subscriptions	Positive (+)	BSS Operator/External/Municipality
Quality of service	Positive (+)	BSS Operator

- **Utilization rate**

Internationally many operators do not report usage rates of their fleet. Some operators who do report, have a very wide range of trips/bike/day (E. Fishman et al., 2014). On a continuous scale, this would result in a utilization rate of the shared bicycles, this would be calculated by 'bicycles in use' divided by the number of shared bicycles in the city.

$$Utilization\ rate = \frac{Shared\ bicycles\ in\ use}{Number\ of\ shared\ bicycles\ in\ city}$$

Factor	Influence	Stakeholder with influence
Number of shared bicycles in the city	Negative (-)	Municipality/Operator(s)/ External
Bicycles in use	Positive (+)	BSS Operator

- **'Negative' use of public space**

This factor is important for the BSS design because authorities have a growing interest in how public space is used and to what function it is allocated. This factor is therefore connected to the utilization rate. In relation to BSS, the use of space is negatively associated when bicycles are not used for a longer time and occupy bicycle parking space. The use of public space when bicycles are used riding on the road are positive for the functioning of the system and are therefore associated positively by the public.

$$Operating\ area = \text{ total area of the municipality}$$

$$Negative\ use\ of\ public\ space$$

Within geofence:

$$= \frac{\text{Redistribution quality} * (0{,}0000012 * ((1 - \text{Utilization rate}) * \text{Number of shared bicycles}))}{\text{Geofence}}$$

Outside of geofence:

$$= \frac{(1 - \text{Redistribution quality}) * (0{,}0000012 * ((1 - \text{Utilization rate}) * \text{Number of shared bicycles}))}{\text{Operating area} - \text{Geofence}}$$

Factor	**Influence**	**Stakeholder with influence**
Utilization rate	Negative (-)	Operator(s)/ External
Operating area (km²)	Negative (-)	External
Redistribution quality	Negative (-)	Operator(s)/Municipality
Amount of shared bicycles in the city	Positive (+)	Municipality
Geofence	Positive (+)	Municipality

- **Bicycle sharing user subscriptions**

  The current bicycle sharing operators are working with subscriptions. The fee for deposit is varying per operator. Some are using discounts for students or at certain action periods, they are lowering the fee. This fee is mostly presented as a deposit for good behaviour with the bicycles and to not return the deposit if the user is to blame if the damage is found to the used bicycle. Based on the three potential users of a BSS; inhabitants, tourists and commuters. In Barcelona, the city decided that the BSS could only be used by inhabitants (Murphy & Usher, 2015).

Factor	**Influence**	**Stakeholder with influence**
Deposit Fee	Negative (-)	Operator
Subscription fee/ year	Negative (-)	Operator
Other operator specifications	Positive/Negative (+/-)	Operator
Inhabitants in city	Positive (+)	External
Tourists in the city	Positive (+)	Municipality (can tourists join the scheme? – example Madrid)
Commuters in city	Positive (+)	External

- **Redistribution quality**

  With the quality of redistribution is meant the distribution of bicycles over the city in relation to potential users in the city and the distance between the bicycles. The better

this fleet is redistributed over the operating area, the better the bicycles will be used, which contributes to a better utilization rate. This redistribution can both be conducted by the operators or by the users by using nudges, see example in Appendix E.

Redistribution quality is based on the effort the operators make to re-balance and remove wrongly parked bicycles into the allowed geofence area. This redistribution quality factor is the fraction of bicycles that are not in use and is located within the geofenced area. So, if 95% of the bicycles is within the geofence, the redistribution quality = 0,95. Also, the optimal distribution is taken into account in this factor.

$Redistribution\ quality = \%$ of stationary shared bicycles inside geofence and according to the optimal distribution

Factor	**Influence**	**Stakeholder with influence**
Redistribution by operators	Positive (+)	Operator(s)
Nudge redistribution by users	Positive (+)	Operator(s)/Municipality

- **Fees from operators**

  Authorities of a city could think of introducing fixed fees for operators with a BSS in the operating area. These fees can consist of an annual permit fee per operator for the overall operation (Seattle Department of Transportation, 2017). Based on the fleet size of the operator an administrative fee per bike can be established which obviously will be more if the operator wants to grow in terms of fleet size. Still, the authorities can set a maximum per operator to reach an optimal functioning system.

  The legal justification for these fees could lie in the fact that public space is used for commercial activities and extra monitoring by civil servants and therefore an operators fee for the use of public facilities and workforce can be legitimate.

Factor	**Influence**	**Stakeholder with influence**
Number of BSS operators in the city	Positive (+)	Operator(s)/Municipality
Number of shared bicycles in the city	Positive (+)	Operator(s)/Municipality

- **Investment in bicycle-related subjects**

  Since policymakers and operators have a common interest in good cycling behaviour and qualitative cycling facilities. The collected fees from operators can be reinvested in cycling related subjects to improve the overall cycling culture. The direct investment in related facilities and programs for improving the cycling culture can create goodwill by the operators, inhabitants and other stakeholders (Vélo Mondial, 2018).

Factor	Influence	Stakeholder with influence
Fees from operators	Positive (+)	Operator(s)/Municipality

- **Geofence**

A geofence can be part of the program of requirements where operators have to conform to, to get a permit/license for operations. This geofence is a digital 'fence' determined by the authorities where the shared bicycles are allowed to be parked. Geofences can be very small and local or the total operating area can be surrounded by a geofence, which keeps the bicycles within range for maintenance and redistribution (Gemeente Amsterdam, 2017).

$$Geofence = \% * \text{Operating area}$$

Factor	Influence	Stakeholder with influence
Operating area (km²)	Positive (+)	External
Geofence setting	Positive/Negative (+/-)	Municipality (governance)

- **Cycling initiatives**

These cycling initiatives will be a political choice and can be linked to many cycling related subjects. Three obvious and relevant subjects would be safety in cycling, reducing the number of incidents with cyclists involved (E. Fishman & Schepers, 2016). Social inclusion of less profitable neighbourhoods is also very relevant for the system of BSS because operators would search the most profitable locations for their operations the municipality should steer actively for social inclusion of poorer neighbourhoods and provide a bicycle sharing mobility option for everyone (Kager & Harms, 2017). Thirdly, bicycle infrastructure is an important subject for improvement and maintenance (Rietveld & Daniel, 2004). 'Other goals' represent the related subjects that are not included in this model.

Factor	Influence	Stakeholder with influence
Municipal revenue (Including fees from operators)	Positive (+)	Municipality

- **Positive Cycling culture**

The cycling culture in this model is simplified for practical reasons and is a result of all kinds of cycling policies. Cycling culture is defined here as the set of aspects related to a positive contribution to the bicycle as a mode of transport. Safety, social inclusion and a good infrastructure and facilities like parking racks are key in relation to the bicycle sharing system. It must be noted that cycling culture cannot be affected by policies directly.

Factor	Influence	Stakeholder with influence
Safer cycling initiatives	Positive (+)	Operator(s)/Municipality
Social inclusion in schemes	Positive (+)	Operator(s)/Municipality
Bicycle infrastructure and facilities	Positive (+)	Municipality
Other objectives	Positive (+)	Operator(s)/Municipality
Bicycle ownership	Positive/Negative (+/-)	Inhabitant

- **Bicycle ownership**

  An important factor for authorities is the number of bicycles owned by the public in a city. The current average of bicycles per person is 1,3 bicycle per inhabitant (KiM, 2015). The introduction of shared bicycles should, in the end, contribute to fewer bicycles and therefore less use of public space. The question is if Dutch people are willing to give up their personal bicycle and totally incorporate in a sharing scheme. The quality and accessibility should be fitting for every occasion and must provide a certain comfort.

Factor	Influence	Stakeholder with influence
Inhabitants of the city	Positive (+)	External
Cycling culture	Positive/Negative (+/-)	External

- **Distance to bicycle from a potential user**

  This is the distance that a potential user should overpass by foot to reach the closest bicycle. If the fleet is optimally redistributed the distance between a potential user and bicycle is minimal and someone can easily find a shared bicycle, so users don't make another mode choice. For BSS with docking stations, a maximum of 300 metres to the closest bicycle was used as a benchmark (Murphy & Usher, 2015).

Factor	Influence	Stakeholder with influence
Redistribution quality	Negative (-)	Operator(s)/Municipality
Geofence setting	Negative (-)	Municipality

- **Negative image BSS**

  The negative image of BSS is very much affected by two important factors. The 'negative' use of public space which is on itself influenced by other factors as described before. Another factor is the media coverage influencing the public opinion about the elements and effects of the various systems. It can be noted that a lot of media have written about the systems, which can have a positive or negative effect on the image of BSS.

Factor	Influence	Stakeholder with influence
'Negative' use of public space	Positive (+)	Municipality/Operator(s)/ External
Media coverage	Positive/Negative (+/-)	External

- **Complaints concerning BSS**

  The complaints concerning BSS are mainly raised by negative experiences of inhabitants with shared bicycles in the city. They are an indication for the degree of acceptance in a city and how well the BSS is functioning in terms of disturbance and nuisance in the city. The municipality should be aware of opponents using the same pictures of piled up bicycles as a strong opposing force. The complaints by inhabitants are indirectly formed by the negative image created by the media and the 'negative' use of public space. Nevertheless, in this model inhabitants are described as the number of inhabitants and the positive effect the increase of inhabitants has on the number of complaints concerning BSS.

Factor	Influence	Stakeholder with influence
Inhabitants of the city	Positive (+)	External

Appendix G: Municipal experts interviews

The municipal civil servant respondents included in table 11 are known and made available for the committee but are anonymous for the public. The interviews are transcribed and fully able to judge by the committee. All respondents are working for their municipality in the domain of mobility and therefore are known with the attitude and dealings in relation to shared bicycles in their cities. Some interviewees already dealt with BSS operators and could, therefore, provide very useful information about the behaviour of operators during meetings.

Table 11: Interviewed experts and city characteristics

Ref. Nr.	City	Respondent (only for committee)	Urbanity	Inhabitants(CBS)
1	Enschede		2	157.864
2	Eindhoven		1	226.868
3	Den Haag		1	526.439
4	's-Hertogenbosch		2	152.411
5	Tilburg		1	213.804
6	Groningen		1	202.636
7	Leeuwarden		2	108.667
8	Houten		3	49.300
9	Rotterdam		1	634.660

City	Population density	Cycle mode share <7,5km	Permit tariff €/ shared car (Metz, 2015)
Enschede	1120	35%	€567
Eindhoven	2588	32%	€102
Den Haag	6429	25%	€277
's-Hertogenbosch	1805	30%	unknown
Tilburg	1824	32%	€155
Groningen	2596	46%	€64
Leeuwarden	704	42%	€418
Houten	895	37%	unknown
Rotterdam	2943	23%	€66

Appendix H: Interview outline

Guideline interview questions with Dutch municipalities in Dutch (English translation file available at request).

A. Introductie
Mijn naam is Yorik Janmaat, student aan de TU Delft. Mijn afstudeeronderzoek gaat over deelfietsen in Nederlandse gemeenten. Ik focus mij op de dockless variant omdat die mogelijk de komende jaren op verschillende gemeenten af gaan komen en daarnaast nog vol in ontwikkeling zijn. Graag hoor ik van u hoe de gemeente hiermee omgaat en wat met betrekking tot deelfietsen al is voorbereid of bedacht. U kunt gewoon vertellen wat u denkt en ervaren hebt, alle informatie is welkom.

1. Wat is uw functie binnen de gemeente?
2. Hoe ziet u de huidige fietscultuur in uw stad?
3. Wat zijn de fietsbeleid focuspunten in de afgelopen jaren geweest en voor de komende jaren?
4. Zijn er in het verleden grote fietsinnovaties geweest en hoe zijn deze toegepast? (of gefaald?)
5. In hoeverre zijn deelfietsen een thema geworden binnen de gemeente?
6. Hoe ziet u het fietsparkeerbeleid samengaan met potentiële komst deelfietsen?
7. Sterke en zwakke punten van dockless bicycle sharing?
8. Hoe ziet u dockless deelfietsen mbt mobiliteit, waar ziet u kansen?
9. Wat zijn uw verwachtingen mbt mode shift/modal split veranderingen als gevolg van deelfiets?
10. Verwacht u een afname van het totaal aantal 'private' fietsen? Ziet u kansen voor ruimtegebruik?
11. Welke nog niet besproken effecten verwacht u in een middelgrote tot grote stad?
12. Hoe ziet u de publiek-private samenwerking bij dockless deelfietsen?
13. Wat vindt u van het gebruik van de publieke ruimte en de publieke ruimte als uitgiftepunt van een service/goed?
14. Bent u bekend met geofencing en ziet u dit als een mogelijk geschikte oplossing voor ruimtegebruik?
15. Wat zou kunnen bijdragen aan meer vertrouwen tussen gemeenten en deelfietsaanbieders?
16. In Amerika wordt vaak de term "Equitable distribution of service" gebruikt, hoe ziet u "rechtvaardige verdeling van de dienstverlening" in het Nederlandse domein? Belangrijk punt?
17. In hoeverre moeten deelfietsen mogelijk als openbaar vervoer worden gezien? Wat zou dit betekenen voor de kostenverdeling publiek/privaat?
18. Hoe kijkt u aan tegen deelfietsdata mbt privacy en delen met gemeente? Wat zijn de kansen en bedreigingen?
19. Hoe ver is de gemeente in het omgaan met data en mogelijk ten goede gebruiken voor fietsbeleid?
20. Welke overige belanghebbenden zijn van invloed op de ontwikkeling en mogelijke implementatie van deelfietsen in uw gemeente?

21. Aan welke maatschappelijke doelen kunnen deelfietsen met name bijdragen wat u betreft?
22. Moet een deelfietssysteem alleen voor bewoners worden ontworpen of ook rekening houden met toeristen als doelgroep?
23. Hoe ziet u de financiële haalbaarheid van deelfietsen, met in het achterhoofd kosten en baten van zo'n systeem?
24. Bent u bekend met de Chinese "deelfiets situatie", heeft dit uw kijk op deelfietsen beïnvloed?
25. Wat ziet u als belangrijkste eigenschappen van een deelfietssysteem voor de gemeenschap om ook daadwerkelijk de deelfiets te omarmen en een wezenlijk onderdeel van het vervoerssysteem te maken?

Appendix I: Flickbike trip data specifications & analysis

Data were retrieved from Vikenti Kumanikin, owner of Flickbike. This operator of dockless shared bicycles introduced 1000 bicycles in the summer of 2017. Users could unlock the bicycles with an application for Android or iPhone. During the period of operation, there were 6.282 registered users (van Waes et al., 2018).

The data was send anonymized in a raw data file. It was retrieved as a comma separated values (.CVS) file. General information about the dataset:

- Trip data from June 30 until October 23 (2017)
- 1000 bicycles initially, some were vandalized or taken out of the fleet for maintenance
- 24.440 trips in the data set
- July 3, 2017, was the official launch of operations

Table 12: Attributes in Flickbike data set

	Column	Coding variable	Name of variable
1	A	tripID	Trip identification
2	B	userid	User identification
3	C	bikeID	Bike identification
4	D	bikenumber	Bike number
5	E	start_time	Start time of the trip
6	F	end_time	End time of the trip
7	G	Duration_in_mins	Duration in minutes
8	H	Distance	Distance in metres
9	I	Start_lat	Start latitude
10	J	Start_lng	Start longitude
11	K	End_lat	End latitude
12	L	End_lng	End longitude
13	M	Date	Date of trip
14	N	Country	Country of origin user
15	O	PostCode	Code of residents
16	P	City	City of residents

Remarks on the use of the data set:

- Solely general fleet analysis was executed, so no privacy issues would occur
- Attribute 'UserID' was not used
- End latitude and longitude were not always registered correctly, so only begin coordinates were used for visualisation of the usability patterns
- Average distance was calculated based on the average duration an approximated average speed of 16,5 km/u, since attribute 'distance' was not always registered correctly, due to GPS failure
- The calculations were made using Excel and visualization by using My Google Maps (Appendix J)

Data analysis

The data analysis of trip data contained 24.440 trips during the time of operation from July until October, more details on the data set can be found in the previous paragraph.

The trip characteristics found from the data set were:

Average duration: 2:55 minutes
Average distance: 800 metres
Trips made by Dutch citizens: 85%
Trips made by Foreign users: 15% (specification of foreign users defined in figure 10)

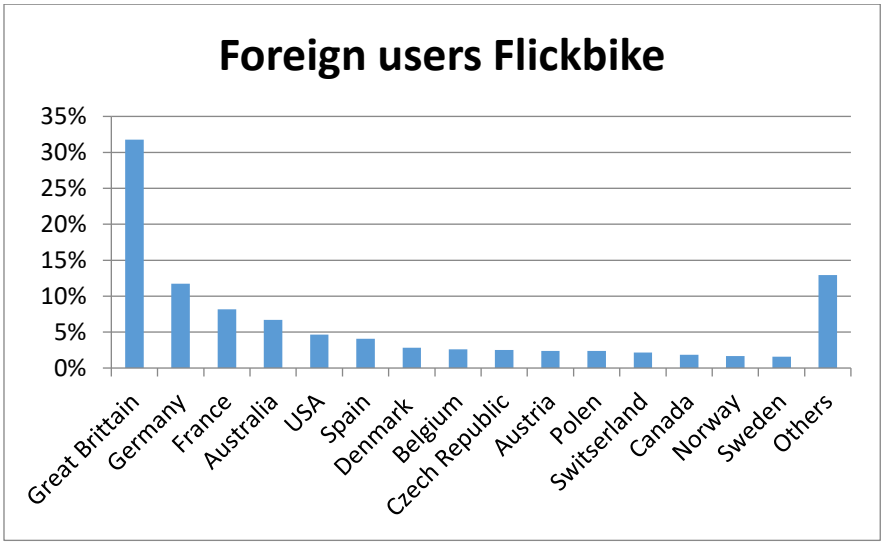

Figure 19: Foreign users of Flickbike

As stated the average distance of a trip was 800 metres and the duration of a trip was 2:55 minutes on average, which is considerably short. As stated in the literature chapter, Midgley (2011) executed research on the role of bicycle sharing in urban mobility and identified the trip costs and trip lengths of other modes of transport. He concluded that bicycle share trips are typically short and considerably shorter than private bicycle trips. This shows that the trip length and duration of Flickbike trips were not abnormally short in contrast to foreign examples. Most trips were executed in the city centre of Amsterdam, as can be seen in Appendix J.

Another interesting result was the days and time of use of shared bicycles. In figure 20 the *number of trips per day of the week* is presented and in figure 21 and 22 trips on *weekdays* in contrast to *weekend* trips are visualized. The moments of use are identified per half an hour.

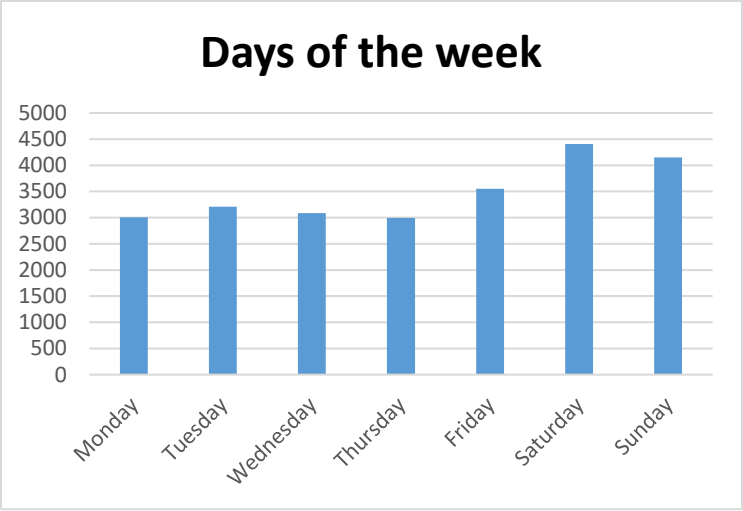

Figure 20: Usage at days of the week

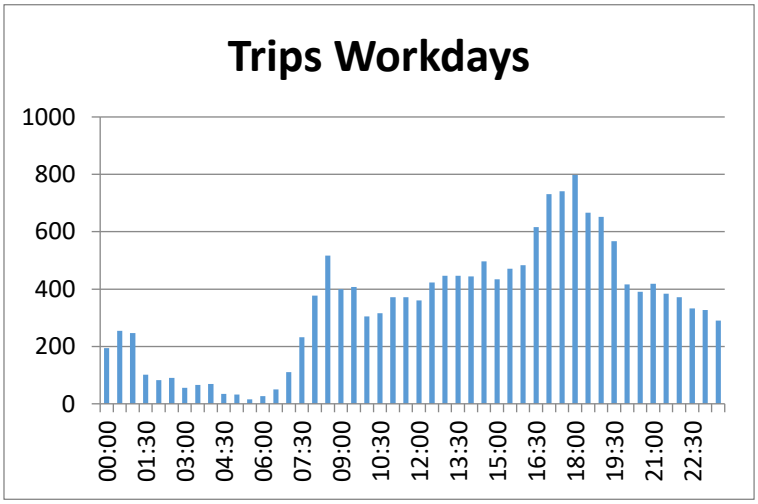

Figure 21: Moment of use free-floating BSS (workdays)

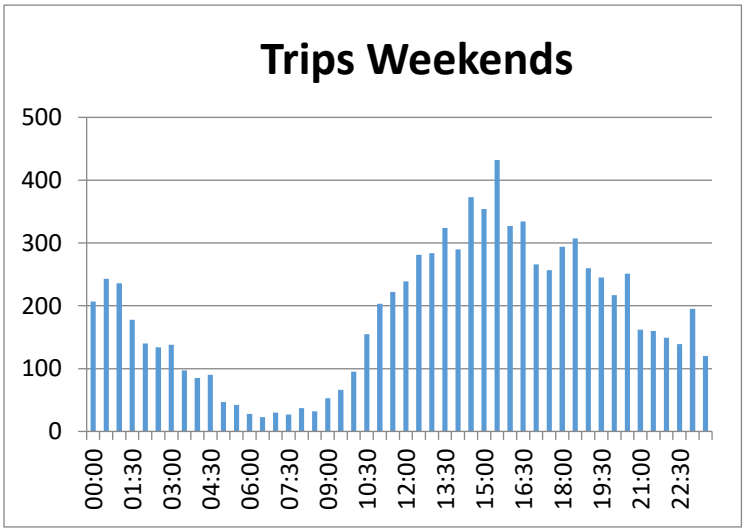

Figure 22: Moment of use free-floating BSS (weekends)

Figure 21 shows that Flickbike had increased usage during peak hours, which shows that Flickbike was used by commuters in the morning rush hour at 8:00. After this peak hour, the usage drops and slowly increases again toward the peak hour at 18:00. This can be identified as typical weekday behaviour of the system and is similar to usage in a study of Reiss & Bogenberger (2015) in the city of Münich. The same peak hours can be identified and also the small increase in usage at 14:00-14:30. The usage pattern during a weekday in Münich is presented with the blue line in figure 9 in paragraph 3.3.

The weekend trips are also very similar to the Münich mobility pattern. In which Flickbike trips during the weekend around 01:00 can be increased by the absence of public transport during the night, as shown in figure 22. This can indicate that dockless BSS can be very useful as a substitution for public transport, which is identified as public value by seven municipalities.

Appendix J: Spatial distribution of Flickbike trips

Flickbike operated in all districts of Amsterdam, shown in figure 23. The eight districts of Amsterdam are visualized according to the index. The bicycles could be picked up and parked in every district within the borders of the municipality. In figure 24 the coordinates of 4000 of the 24440 trips are visualized, these amount of trips give a good indication on the mobility patterns of Flickbike, it shows that most trips were executed in the city centre.

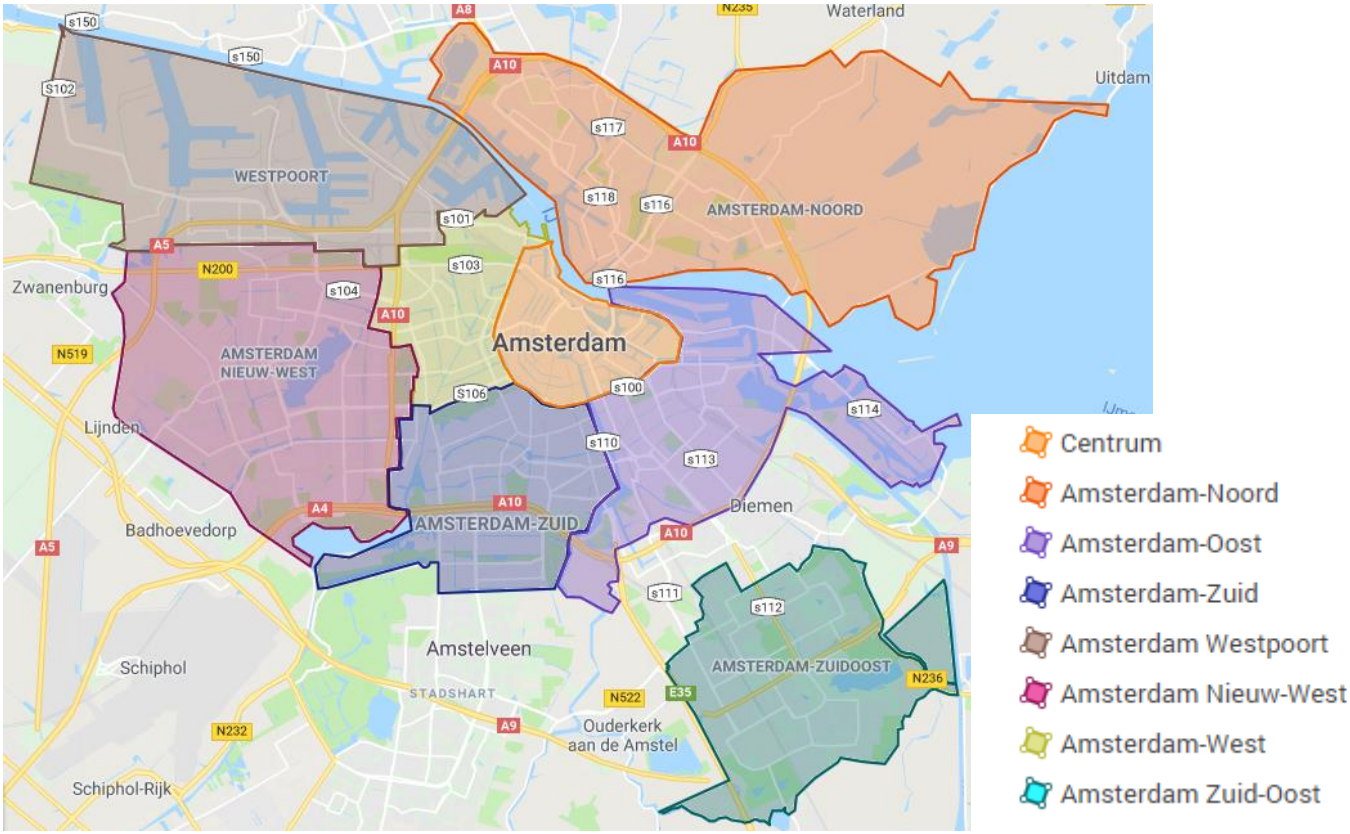

Figure 23: Operating area of Flickbike in 2017

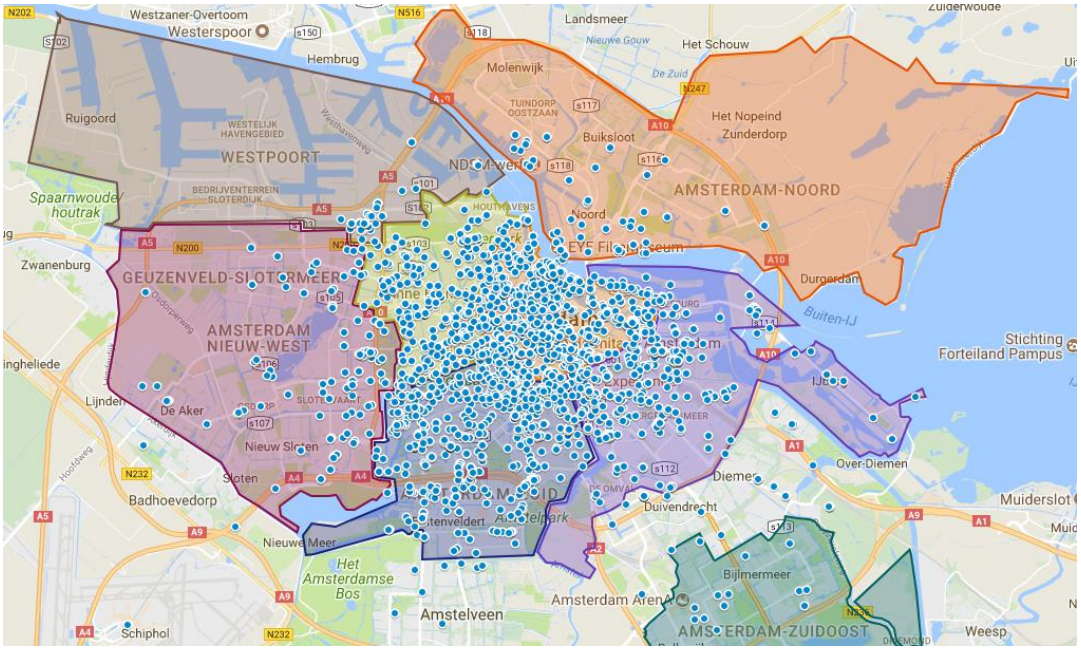

Figure 24: Spatial distribution of Flickbike trips

Appendix K: Universal logo sharing modalities

Since car sharing is ahead of the development of bicycle sharing, lessons can be learned from measures that are introduced by authorities and private agencies. Once it was clear that car-sharing was developing and would play a role in the field of mobility, several long-term objectives were monitored. In addition, a general logo was developed to communicate with the public (Platform Autodelen, 2018).

Other roles of 'Platform Autodelen' :

- Monitoring the number of operators in the Netherlands
- Monitoring the number of shared cars in the Netherlands
- Monitoring the number of shared cars per municipality
- A questionnaire about users and usability performance to operators
- Independent platform for knowledge sharing and stakeholder meetings

Figure 25: Spin-off logo for bicycle sharing from car sharing example