Think Green – Bike!
The Bicycle Sharing System in the Smart City Barcelona

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ABSTRACT

One of the main goals of every (aspiring) Smart City is a green-minded, sustainable development. Today, one of the most popular green Smart City trends is the provision of bike sharing systems. In this study, we evaluate the *Bicing* service in Barcelona, which is one of the "smartest" cities in Europe. The investigation is based on a rapid ethnographic field study, qualitative interviews as well as a quantitative online survey among Barcelona's residents and people staying in Barcelona for work, study or other reasons (e.g. shopping), all of which ensure a user-centric approach. The results show some strengths as well as weaknesses of the service and enable us to deduce important rules for implementation of bike sharing systems.

Keywords: sustainable development, sustainable service, bike sharing system, urban development, strengths and weaknesses

1. Introduction

How can citizens take over the responsibility and put an end to the air pollution and congested roads? Obviously, by deciding to be more green-minded. But how can citizens live more environment-friendly, if there are no green-minded alternatives? This is the reason why we need more sustainable and eco-friendly infrastructures and services in today's cities. With integrating Information and Communication Technology (ICT) in everyday life, simple aspects such as riding a bike become influenced by ICT, too. After introducing and developing bicycle sharing systems, the users need certain information (where is the next free bike, where can I return my bike and so on), they also produce data and use the service with an electrical card, mobile app or QR-Code scanner. All in all, with the upcoming of smart cities and ICT, services are not only allowing the support of sustainable growth and changes, but also change the way how people behave and conflate information and communication technology with activities such as riding a bike. Of course, there is no perfect solution and many researchers, practitioners and smart city developers constantly try to match up to the environmental challenges. Besides electrical public and private transport possibilities to reduce exhaust gas pollution, many cities all over the world offer bicycle sharing systems.

Some examples of bike sharing systems are YouBike (Taipei), BiciMAD (Madrid), Viu BiCiNg (Barcelona), Nextbike (Germany), Ofo, Mobike (China), Forever (Shanghai) BIXI (North America), Santander Cycles (London), The Vélib' (Paris), Citi Bike (New York City), O'Bike (Muscat) and Q Bike (Doha). Why are these bike-sharing systems booming at the moment? According to Munkácsy and Monzón (2017, p. 621), they are "eco-friendly, relatively cheap, efficient both individually and on first/last mile of intermodal trips, etc.", but also today's technology "makes them easy-to-operate and easy-to-use". Bike sharing systems are not only interesting for their users. They have also drawn the attention of many scientists as a lot of scholars did various researches on different aspects of this topic. Castillo-Manzano, López-Valpuesta and Sànchez-Braza (2016) investigated the motivation of cyclists to use either private or the sharing bikes. They found out that the decision to take the private or the public bike depends on the length of the route. Furthermore, as the bike-sharing program grows very fast in Asia, especially Chinese scholars did research on different bike-sharing aspects. For example, they compared several bicycle sharing systems in Chinese urban areas regarding their characteristics and similarities (Zhang, Zhang, Duan, & Bryde, 2015). There are also some user-centric studies, for example, Yang (2013) investigated the intention and behavior of YouBike users in Taipei. Interestingly, bicycle sharing services are not as new as one would think, as the first generation of bike-sharing system was introduced already in the 60's in Amsterdam (Midgley, 2011).

This paper focuses on the bike sharing system in Barcelona, which is the 2nd largest city in Spain. Why Barcelona? This city is assumed to be one of the smartest cities in Europe and "is considered as a success story in urban development across Europe" (Bakici, Almirall, & Wareham, 2013, p. 136). Barcelona's transformation into a smart city is characterized by "having a simple and effective, closer to citizens, connected, ubiquitous, and innovative public (local) administration" (Gascó, Trivellato, & Cavenago, 2016, p. 195). One of many smart services (e.g. mobile parking application, noise sensors, free WiFi, parking sensors, open data, etc.) in Barcelona is the bike sharing system *Viu BiCiNg*. Our approach during the conducted study concentrated on the usage behavior (users' characteristics) and the strengths and weaknesses of the service (perceived smart service quality and acceptance of the smart service). How satisfied are Barcelona's residents and all other people staying in Barcelona and do they really need such bike-sharing system? As there are many different concepts of bike-sharing systems, is the service easy to use? These and other questions will be answered in this paper.

The bicycle sharing system *Viu BiCiNg (short: Bicing)* has 104,686 subscribers, includes 6,000 bicycles and 420 *Bicing* stations (Bicing, n.d.). The sharing system enables residents of Barcelona to be mobile in a sustainable way. As a first step, the residents need to register and pay an annual fee of 47.16€. After they received their *Bicing* bike card, they can start using the *Bicing* bikes. To be a *Bicing* bike user, one needs a Número de identidad de extranjero (NIE), which is the Spanish tax identification number of foreigners, or the Documento nacional de identidad (DIN), the Spanish identification number. Therefore, tourists without such identification number cannot use this service. The service is a semi-free trial and the first 30 minutes after taking a *Bicing* bike from the station are free-to-use. Every half hour after the first 30 minutes costs about 0.74€. The maximum duration of using one bike after the first 30 minutes is 2 hours. After exceeding the allowed time, the user gets a penalty of 4.50€ for every additionally exceeded hour (Bicing, n.d.).

Figure 1. *Bicing* service in Barcelona. Right below: Anchorage Point 1, left: electrical pillar to pick up/bring back a *Bicing* bike, right above: a *Bicing* bike station. Photo: Aylin Ilhan

There are 420 *Bicing* stations located in an immediate proximity to places with a high fluctuation of people or at local sights, for instance, subway stations, train and public car parks, libraries, community centers and so on (Figure 1). To take a bike, the user has to put his/her card in front of the electrical pillar (Figure 1) and wait until the number of the available *Bicing* bike is displayed. The numbers are placed next to the clamps. Locks are not needed, as the bikes are equipped with anchorage points and clamps.

The use of the service is supported by an application for the smartphone. With the *Bicing* app users can get information about free or full stations, or where the next station is located. The management of the 420 *Bicing* bike stations follows a cluster concept, as it would be too difficult to manage every station separately (personal communication, 02.08.2016). It is a vital feature of the clusters that the stations are located near to each other, since clustering would not make sense otherwise. Normally, one cluster consists of two to three *Bicing* stations. Nevertheless, larger cities such as Barcelona are frequently confronted with problems like vandalism. Consequently, this has an effect on the state of the service (e.g. damaged bikes/stations, stolen bikes) (personal communication, 02.08.2016).

2. Methods

The purpose of this study is to evaluate one of Barcelona's smart services, the *Bicing* bike sharing service. To evaluate users' experience with this service and mobile application as well as factors that support the sustainable development of a city or green-minded behavior of a user, we conducted an online survey. This online survey was distributed (June 8, 2016 till August 20, 2016) through different groups in social media channels (e.g. Facebook and LinkedIn) and by e-mail with help of lecturers and researchers in Barcelona. Most questions in the survey were based on a 7-point Likert scale (1 – "Strongly disagree" up to 7 – "Strongly agree"). The survey was written in English and set up with the free online survey tool *umfrageonline*. All in all, 309 participants took part and 168 completed the survey.

The survey was based on a theoretical model framework, the Information Service Evaluation (ISE) model (Schumann & Stock, 2014). The model includes different well-known evaluation models, such as the UTAUT (Venkatesh, Morris, Davis, & Davis, 2003), TAM (Davis, 1989), MATH (Brown & Venkatesh, 2005).

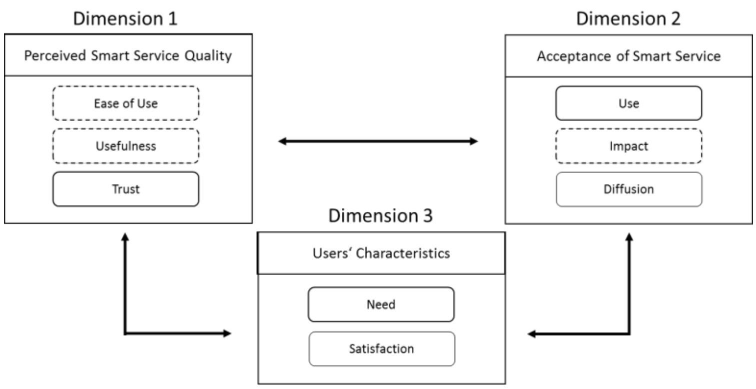

Figure 2. Our research model.

Dimension 1 of the adapted and modified ISE model (Figure 2) represents the perceived smart service quality and includes the aspects ease of use (Venkatesh & Davis, 2000), usefulness (Venkatesh & Davis, 2000) and trust (Gefen, Karahanna, & Straub, 2003). Besides the perceived service quality, the acceptance of such service is also important.

Dimension 2 represents this important issue and consists of the indicators use, impact and diffusion. The original model by Schumann and Stock (2014) additionally includes the indicator adoption, but it was omitted for the investigation of this service. The last important dimension (Dimension 3) concentrates on the users themselves – more precisely, on their needs and satisfaction with the service. If someone is not satisfied with a service, the success of this service and the need for it will stagnate: "If the system does not provide the needed information, the user will become dissatisfied and look elsewhere" (Ives, Olson, & Baroudi, 1983, p. 785). Self-evidently, satisfaction with a service can be increased with "the ease of accessing, learning and using the system, […] robustness, and so on" (Lee & Pow, 1996, p. 172). Therefore, besides the traditional dimensions (Dimension 1 and Dimension 2), the two indicators, satisfaction and need, are also of importance in our research model. It is crucial to find out, which aspects worsened or improved the satisfaction with the service and users' need for it. This study answers the following two research questions (RQ) based on the research model:

RQ1: What are the usage characteristics as well as the strengths and weaknesses of *Bicing*?

RQ2: Are there correlations between the perceived smart service quality of *Bicing* (Dimension 1), the acceptance of this smart service (Dimension 2) and the users' characteristics in terms of need and satisfaction (Dimension 3)?

To answer RQ2 we calculated the Spearman's rank correlation. As our survey includes different items (see Appendix) we use Cronbach's α to test the internal consistence of the items.

For a better understanding of Barcelona's smart city concepts and services we conducted interviews with people being in charge of smart services, for example, with the manager of the *Bicing* sharing service. Interviews are one of the best methods to collect qualitative data (Qu & Dumay, 2011). Furthermore, to get a better general impression about the services, our research was based on the 'rapid' ethnographical field research (Millen, 2000). It is "a form of multi-method ethnography involving data collection from numerous sources over a relatively short period including interviews, participant observations, document review and sometimes surveys and focus groups" (Baines & Cunningham, 2011, p. 74). The field study was conducted from April 3rd, 2016 to April 11th, 2016.

3. Results

3.1 Usage of *Bicing* bikes (RQ1)

Providing a well-developed service is how developer can attain great success, however, the actual use of such service is the important and deciding part. Only 31% of 167 respondents in our survey said that they use the service *Bicing* (Figure 3). This outcome is very disconcerting, since the ethnographical field research showed that there are many *Bicing* users and a lot of empty station, which means the *Bicing* bikes appear to be popular. It is possible that the survey did not reach the right target group.

Today it is usual that a lot of services are supported by complementary apps. The *Bicing* bike app is used by more than a half (64%) of participants using the service (52 participants). The app offers, for example, information about free *Bicing* stations or stations where an interested user could take a *Bicing* bike. To take a bike from any *Bicing* station a registered *Bicing* card is necessary. The results show that some of the respondents (14%) do not have their own *Bicing* card. Probably, they use a card belonging to their friends or family members.

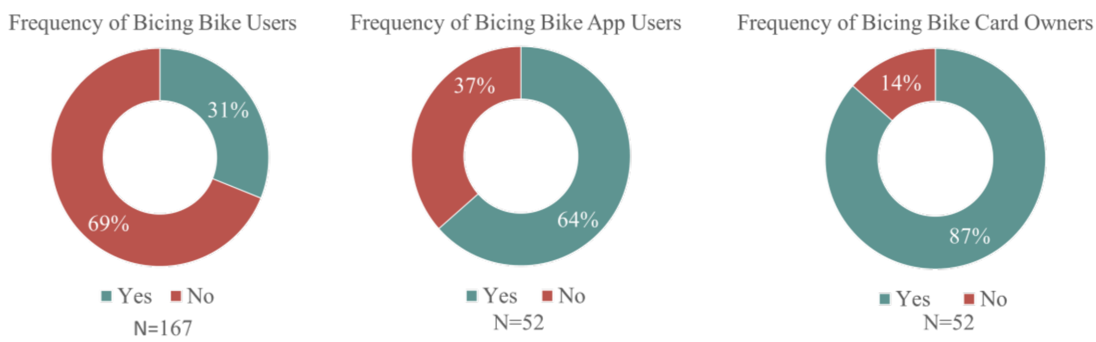

Figure 3. Share of *Bicing* bikes users.

What are the reasons of about 69% of our respondents (115 participants) to not use this service? Figure 4 shows that many non-users prefer to use other public means of transportation (68%). Participants had the possibility to choose multiple reasons why they do not use this service. Others (23%) address, for example, the infrastructure of the streets: "I use public transport because there is no proper infrastructure for riding the bicycle and people do not respect the traffic rules – not feeling comfortable to ride a bike here", "biking in [Barcelona] is dangerous", "there isn't sufficient infrastructure", and the state of bikes and stations: "It starts as a good service, but it became more and more expensive and less satisfying broken bikes, broken parking, no bikeways …", "I used to use it, but there were problems (vandalism, stations didn't work, etc.); might try it again in the future", "always broken/empty/full". Other reasons, why respondents reject the service, are the prices: “price too expensive” and “this is expensive”. One participant admitted that he/she “can’t ride a bike”, or another one told that he/she prefers to walk. When considering aspects like the prices or broken stations and bikes, it is comprehensible that people prefer to keep on using their own bikes (21%) or the car (11%). Besides the aspect that a resident is not able to ride a bike, 5% do not like to bike and 8% selected the answer ‘I am not satisfied with the service’. The results of the answer option ‘Others’ showed that some of the participants adopted the service but then stopped using it.

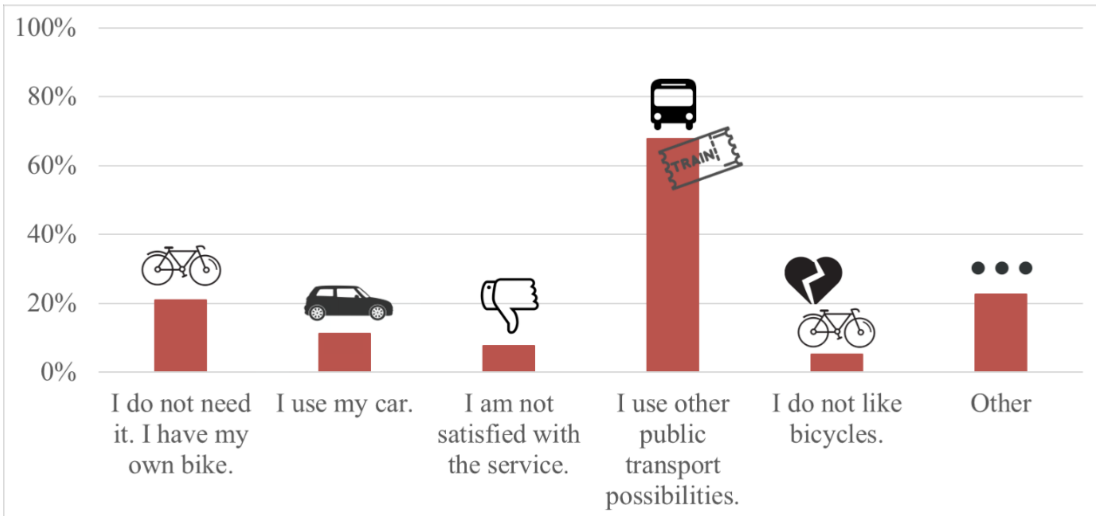

Figure 4. Reasons for rejecting *Bicing*; N=115.

Figure 5 shows that most of the 52 respondents use the service several times a week (37%) and 25% less often than once a week. More users use the service once a day (17%) than the ones who do it several times a day (14%).

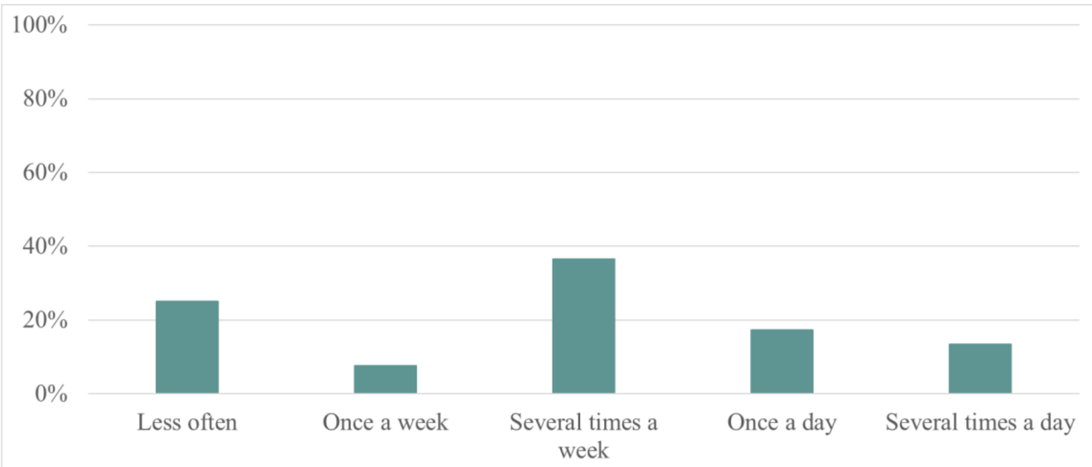

Figure 5. Frequency of use of *Bicing*; N=52.

Besides the frequency of use, Figure 6 contains probable reasons why the respondents do not use the service frequently. 46% of 52 participants agree that the prices for more than 30 minutes are high and 83% of the 52 respondents confirmed that they use the service only for routes within 30 minutes. If you use a bike within 30 minutes it is free, after 30 minutes, every further 30 minutes till 2 hours bring costs. The maximum time of using one bike is 2 hours as the service *Bicing* is not a rental, but a sharing service. People should share the bikes so that every user can benefit from the service.

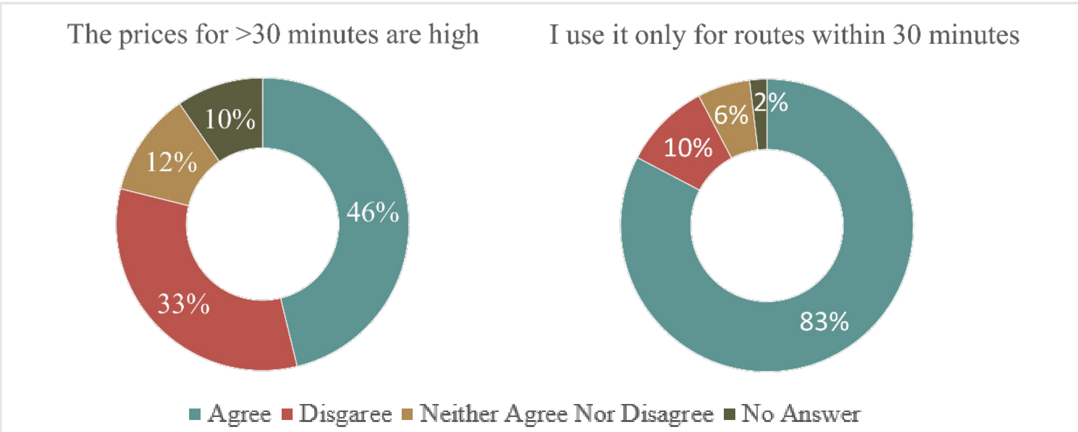

Figure 6. Probable reasons hindering frequent use of *Bicing*; N=52.

To understand why a service is successful, it is important to analyze its strengths and weaknesses. Here, two important aspects are in focus: the technical functionalities and the logistic proposal.

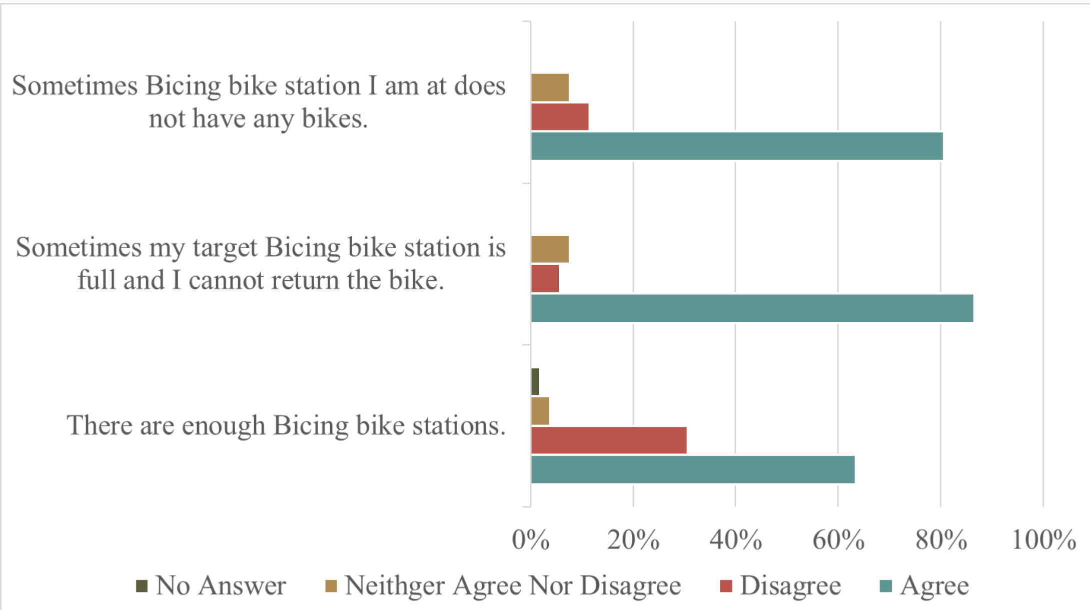

Figure 7. User satisfaction concerning the logistic proposal of the *Bicing* service; N=52.

Concerning the logistic proposal, Figure 7 shows that there is still some room for improvement. With 420 *Bicing* stations, there appear to be 'enough *Bicing* bike stations', according to 63% of the respondents. The amount of stations in Barcelona seems to be not the critical aspect. The respondents are more dissatisfied with a logistical problem, namely, when they want to return a bike and a station they are at is full, or when they want to take a bike and the station is empty. This forces the users to go to the next station and might in the longer-term discourage them from using the service.

The technical functionalities are another important aspect (Figure 8). Almost all respondents (94%) are satisfied with the card system as they agree that it is easy to use. Since 69% of the participants agree that the card system operates without any technical problems, we assume that some technical malfunctions may occur from time to time as the remaining participants experienced them to some extent. To get a satisfied *Bicing* user it is advisable to offer an easy registration structure, without frustrating or overcharging people. Apparently, *Bicing* developers were aware of it, as 83% of the 52 participants agree that it is easy to order the card.

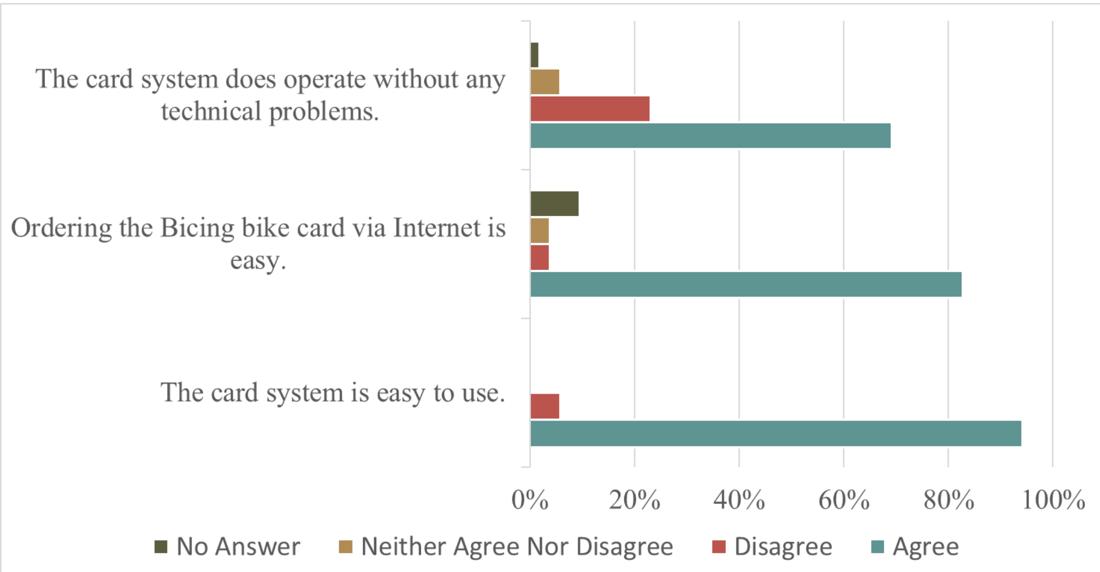

Figure 8. User satisfaction concerning *Bicing's* technical functionalities; N=52.

A lot of cities try to support their green infrastructures by offering bicycle sharing systems. Do people recognize that such services could be a step towards a greener city? As Figure 9 shows – yes, they do. 98% of respondents agree that the service contributes to the sustainable green minded development of Barcelona. Furthermore, it has not only an impact on the city itself, the people who are living in the city are also affected. 64% confirm that they feel more green-minded than before. It is on the dice that such systems are also very convenient. People can use the bicycles more often than other transport possibilities and if everything works well (for example, no full stations when returning the bike), they do not have to worry about where to leave their bike.

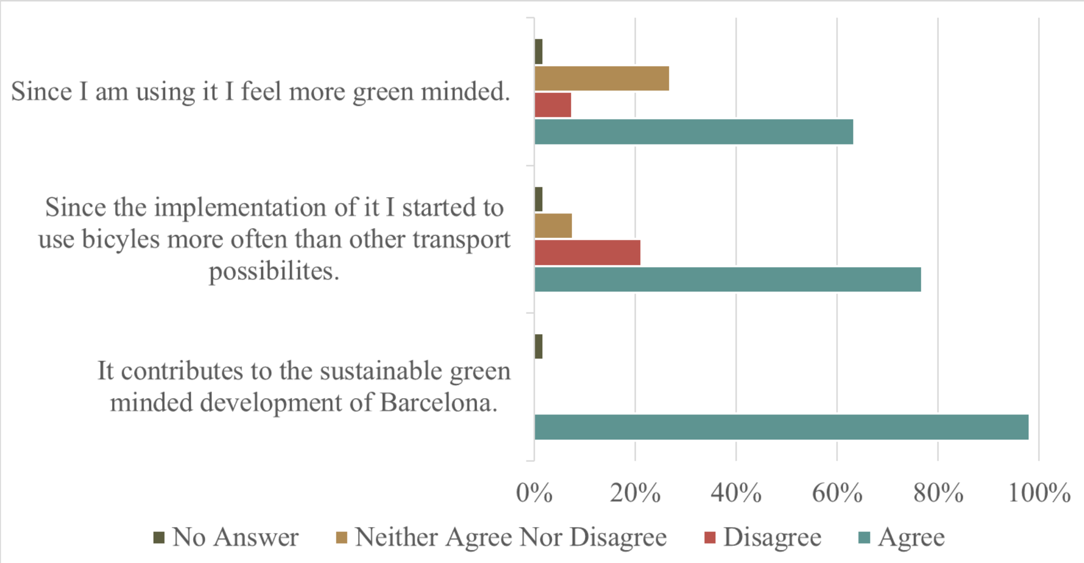

Figure 9. *Bicing* and user awareness of sustainability; N=52.

3.2 Correlations between Perceived Service Quality, Acceptance and Users' characteristics (RQ2)

Our survey included several different questions about the *Bicing* service. Before correlating the items, we tested the internal consistency of them with Cronbach's α. To sum up items to one indicator and get acceptable results, the value had to be higher than +0.7. This requirement was met for only two indicators, the Logistical Proposal1 (sums up two items, Cronbach's α =+.801) and Diffusion (sums up two items, Cronbach's α = +.792). The remaining indicators were considered individually. Table 1, Table 2 and Table 3 include the correlations. The values of the correlation must be interpreted bidirectional as the variance is not calculated by deeper analysis. As our data is measurable on an ordinal scale, we calculated the Spearman's rank correlation.

Is there a rank correlation between the perceived smart service quality (Dimension 1) and the acceptance of smart services (Dimension 2)? The answer is yes. Both dimensions correlate related to different items of indicators. The item 'Technical Functionality1' of *Ease of Use* and the item 'City Performance' of *Impact* correlate significantly (+.401**). It means that the simplicity of a system (here, the card system) supports the acceptance of a service and, therefore, contributes to the sustainable development of a city. The usefulness of a service is an important aspect when it comes to its acceptance. Both indicators of *Usefulness* ('Rejection of Public Transport' and 'Rejection of own/a bike') correlate significantly with the indicator *Use* of Dimension

2. The indicator 'Rejection of Public Transport' correlates higher with the indicator *Use* (+.466**) than the item 'Rejection of own/a bike' (+.391**). The more the service is perceived as useful (for any reasons), the more it is used and the more it is accepted. Obviously, if citizens tend to use more often the bicycle than other public transport possibilities, the more impact it has on the city performance (+.407**).

Table 1. Bivariate rank correlation (Spearman's rho) between perceived smart service quality (Dimension 1) and smart service acceptance (Dimension 2).

Spearman-Rho			Dimension 1							Dimension 2			
N=52 (Variance is given)			Ease of Use				Usefulness		Trust	Use	Impact		Diffusion
* p<.05, ** p<.01, *** p<.001			Logistical Proposal1	Logistical Proposal2	Technical Functionality1	Technical Functionality2	Rejection of Public Transport	Rejection of own/a bike	Trust	Use	City Performance	User Performance	Diffusion
Dimension 1	Ease of use	Logistical Proposal1	1	x	x	x	x	x	x	-.059	+.118	+.014	-.029
		Logistical Proposal2	x	1	x	x	x	x	x	+.185	+.111	-.206	-.037
		Technical Functionality1	x	x	1	x	x	x	x	+.079	+.401**	+.011	+.443**
		Technical Functionality2	x	x	x	1	x	x	x	-.128	+.186	+.015	+.396**
	Usefulness	Rejection of Public Transport	x	x	x	x	1	x	x	+.466**	+.407	+.087	+.121
		Rejection of own/a bike	x	x	x	x	x	1	x	+.391**	-.043	+.166	+.119
	Trust	Trust	x	x	x	x	x	x	1	-.035	+.083	+.11	+.360*
Dimension 2	Use	Use	-.059	+.185	+.079	-.128	+.466**	+.391**	-.035	1	x	x	x
	Impact	City Performance	+.118	+.111	+.401**	+.186	+.407**	-.043	+.083	x	1	x	x
		User Performance	+.014	-.206	+.011	+.015	+.087	+.166	+.11	x	x	1	x
	Diffusion	Diffusion	-.029	-.037	+.443**	+.396**	+.121	+.119	+.360*	x	x	x	1

Furthermore, the more the service is perceived as easy to use the more it is diffused into the society. The indicator *Diffusion* of Dimension 2 correlates significantly with two items of *Ease of Use* (+.443** with Technical Functionality1, +.396** with Technical Functionality2). Another important aspect, however a little bit less important than the two items of *Ease of Use,* is the indicator *Trust.* The better a system works (e.g. without technical problems), the more trust it gains (+.360*). Considering the correlations between Dimension 1 and Dimension 3 (user) (Table 2), the indicator 'Logistical Proposal1' (e.g. enough empty bicycle ports and enough free bicycles to take) influenced the satisfaction of a user (-.323*). This negative correlation expresses that the more users disagree that there are not enough *Bicing* stations the more they are satisfied with the service. The better the mentioned logistical proposal works, the more satisfied are the users. It comes as a surprise that the technical functionalities correlate higher with the indicator *Satisfaction* than the 'Logistical Proposal1'. The more the service functions without any technical problems (Technical Functionality2), the more satisfied will be the user (+.532**). This indicator correlates a little bit better with *Satisfaction* than 'Technical Fuctionality1' (+.502**). One indicator of *Usefulness*, the 'Rejection of own/a bike', correlates significantly with Satisfaction (+.310*). Besides the indicator *Satisfaction,* Dimension 3 consists of the indicator *Need*, too. Two indicators of Dimension 1 significantly correlate with the indicator *Need* (+.317* with Ease of Use/Technical Functionality1, +.414** with Trust). People need services in which they can trust and which are easy to understand and can be used with little effort.

Table 2. Bivariate rank correlation (Spearman's rho) between perceived smart service quality (Dimension 1), users' characteristics (Dimension 3).

Spearman-Rho			Dimension 1							Dimension 3	
N=52 (Variance is given)			Ease of Use				Usefulness		Trust	Satisfaction	Need
* p<.05, ** p<.01, *** p<.001			Logistical Proposal1	Logistical Proposal2	Technical Functionality1	Technical Functionality2	Rejection of Public Transport	Rejection of own/a bike	Trust	Satisfaction	Need
Dimension 1	Ease of use	Logistical Proposal1	1	x	x	x	x	x	x	**-.323***	+.093
		Logistical Proposal2	x	1	x	x	x	x	x	-.246	+.022
		Technical Functionality1	x	x	1	x	x	x	x	**+.502****	**+.317***
		Technical Functionality2	x	x	x	1	x	x	x	**+.532****	+.224
	Usefulness	Rejection of Public Transport	x	x	x	x	1	x	x	-.024	+.158
		Rejection of own/a bike	x	x	x	x	x	1	x	**+.310***	+.26
	Trust	Trust	x	x	x	x	x	x	1	+.131	**+.414****
Dimension 3	Satisfaction	Satisfaction	**-.323***	-.246	**+.502****	**+.532****	-.024	**+.310***	+.131	1	x
	Need	Need	+.093	+.022	**+.317***	+.224	+.158	+.26	**+.414****	x	1

For indicators of Dimension 2 and Dimension 3 (Table 3), there is a signification correlation between *Satisfaction* and *Diffusion* (+.509**) as well as *Satisfaction* and the item 'City Performance' of the indicator *Usefulness* (+.321*). The more users are satisfied, the more useful *Bicing* is for them (or vice versa). The more *Bicing* is needed by the users the more the users will recommend it to other friends, family and other cities (+.415**).

Table 3. Bivariate rank correlation (Spearman's rho) between smart service acceptance (Dimension 2), users' characteristics (Dimension 3).

Spearman-Rho			Dimension 2				Dimension 3	
N=52 (Variance is given)			Use	Impact		Diffusion	Satisfaction	Need
* p<.05, ** p<.01, *** p<.001			Use	City Performance	User Performance	Diffusion	Satisfaction	Need
Dimension 2	Use	Use	1	x	x	x	+.033	+.115
	Impact	City Performance	x	1	x	x	**+.321***	+.201
		User Performance	x	x	1	x	+.215	+.019
	Diffusion	Diffusion	x	x	x	1	**+.509****	**+.415****
Dimension 3	Satisfaction	Satisfaction	+.033	**+.321***	+.215	**+.509****	1	x
	Need	Need	+.115	+.201	+.019	**+.415****	x	1

4. Discussion

The critical evaluation of the bike sharing system in Barcelona showed the users' characteristics and the strengths as well as weaknesses of the service. Besides other sustainable transport services in the city, such as hybrid public transports or electrical transport possibilities, Barcelona met the challenge of reducing air pollution and supporting the sustainable development with its *Bicing* service.

All in all, 31% of 168 respondents use the service and the other 69% do not. One weakness of the service is the logistical performance, as the *Bicing* stations are sometimes empty and the user cannot get a bike, or on the contrary, the stations are full and the user cannot return a bike. Furthermore, the study shows that not only the service itself is important but the surrounding circumstances, too. Some respondents mentioned that they do not use it because there is no sufficient infrastructure or that it is dangerous to ride a bike in Barcelona. To get more users and be more successful, an improvement of bicycle paths is necessary. Interestingly, 63% of the users use the *Bicing* app. The app enables real-time information such as 'Where is the next station?' and 'Are there shareable bikes?'.

Total 69% of our participants reject the service and use other public or private transport possibilities. Some of these participants are not interested in the service because they have their own bike (21%). Furthermore, the research shows that some of the respondents used the service for a while and after they got dissatisfied with it, they stopped. Mostly, the service is used by the respondents several times a week (37%). Furthermore, the most participants use the service for 30 minutes (83%) only. This is probably reasonable, since the first 30 minutes are free of charge, and the service is construed as a sharing system. Two other probable reasons why respondents tend to use it for only 30 minutes could be, firstly, the price after the first 30 minutes (since 46% emphasized it is too high) and, secondly, the rather short routes, because they might use it to cycle only to the nearby destinations.

One of the service's strengths is its technical performance. 94% of 52 respondents agree that the card system is easy to use and that it works without technical problems most of the time (69%). As cities try to create solutions to reduce the air pollution and traffic, 98% of the participants confirmed that the service contributes to the sustainable development of Barcelona and 64% agree that the service has an impact on their own green-minded attitude. To raise the acceptance of the service, the research shows that factors such as the 'Ease of Use', 'Usefulness' and 'Trust' of a service positively support the acceptance of it.

Besides the acceptance and use of a service, our results point out that 'Ease of Use', 'Usefulness' and additionally 'Impact' and 'Diffusion' affect the satisfaction of a user. If a user is not satisfied with a service, why should she/he recommend ('Diffusion') it to friends or other cities? Furthermore, if we use a service, we are more satisfied and content if we recognize the positive impact it has on our behavior and surroundings. Based on our results, the most important rule for developers is to provide a trustworthy and easy to use service.

This research confirms that critical evaluation is necessary to understand the strengths and weaknesses of a smart city service and to detect the potential problems and their triggers. To increase the success of a service it is important to get feedback also from users who opted out from using it. A user-centric approach is inevitable to offer the best service. A newest trend built with the latest technology and being no matter how eco-friendly will never be successful, unless it is accepted by the people it is intended for.

5. Conclusion

In this study, we evaluated Barcelona's bike sharing service together with its strengths and weaknesses, and derived some rules that may be important for developers of such systems. Our approach was based on a rapid ethnographic field study, qualitative interviews and, most important, on a quantitative online survey among Barcelona's residents and people staying in Barcelona for work, study or other reasons (e.g.

shopping). The users appear to be content with the service and its technical reliability. The biggest challenge appears to be of logistical nature and concerns overcrowded or empty bike stations. This is one disadvantage of a bike sharing system based on bike docking stations. An investigation of other bike sharing systems without such stations (e.g., in Shanghai) and their advantages and disadvantages could show, which practice is better. When looking at the answers of non-users of the service, it is questionable if there are quick solutions that would change their mind about it. The improvement of the condition of roads and bicycle paths is more of a long-term plan. However, some amendments to the pricing scheme are worth consideration.

For the future, in order to reach more users of the *Bicing* service, an online survey in Spanish language as well as its distribution on further platforms could be beneficial. To be able to make more suggestions how to improve the bike sharing systems all over the world, it would be advisable to compare several sharing systems from different countries. This would enable us to better understand their strengths and weaknesses as well as possible cultural and economic factors influencing the adoption. Since there are so many different concepts of bike sharing systems, which features are mostly preferred? What are the best practices? Which pricing schemes are more convenient? And, how can we make sure that the service makes the citizens happy while assuring city's sustainable development?

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REFERENCES

Baines, D., & Cunningham, I. (2011). Using comparative perspective rapid ethnography in international case studies: strengths and challenges. *Qualitative Social Work*, *12*(1), 73–88.

Bakici, T., Almirall, E., & Wareham, J. (2013). A smart city initiative: the case of Barcelona. *Journal of the Knowledge Economy*, *4*(2), 135–148.

Bicing. (n.d.). Retrieved from https://www.bicing.cat/

Brown, S. A., & Venkatesh, V. (2005). Model of adoption of technology in households: a baseline model test and extension incorporating household life cycle. *MIS Quarterly*, *29*(3), 399–426.

Castillo-Manzano, J. I., López-Valpuesta, L., & Sánchez-Braza, A. (2016). Going a long way? On your bike! Comparing the distances for which public bicycle sharing system and private bicycles are used. *Applied Geography*, *71*, 95–105.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340.

Gascó, M., Trivellato, B., & Cavenago, D. (2016). How do southern european cities foster innovation? Lessons from the experience of the smart city approaches of Barcelona and Milano. In J. R. Gil-Garcia, T. A. Pardo, & T. Nam, (eds.), *Smarter as the New Urban Agenda* (pp. 191–206). Switzerland: Springer International Publishing.

Gefen, D., Karahanna, E., & Straub, D. W. (2003). Trust and TAM in online shopping: an integrated model. *MIS Quarterly*, *27*(1), 51–90.

Ives, B., Olson, M. H., & Baroudi, J. J. (1983). The measurement of user information satisfaction. *Communications of the ACM*, *26*(10), 785–793.

Lee, M. K. O., & Pow, J. (1996). Information access behaviour and expectation of quality: two factors affecting the satisfaction of users of clinical hospital information systems. *Journal of Information Science*, *22*(3), 171–179.

Midgley, P. (2011). Bicycle-Sharing Schemes: Enhancing Sustainable Mobility in Urban Areas. *Commission on Sustainable Development*, *Nine teent Session* (8), 1-24.

Millen, D. R. (2000). Rapid ethnography: time deepening strategies for HCI field research. In *Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods and Techniques* (pp. 280–286). New York, USA: ACM.

Munkácsy, A., & Monzón, A. (2017). Potential User Profiles of Innovative Bike-Sharing Systems : The Case of BiciMAD (Madrid, Spain). *Asian Transport Studies*, *4*(3), 621–638.

Qu, S. Q., & Dumay, J. (2011). The qualitative research interview. *Qualitative Research in Accounting & Management*, *8*(3), 238–264.

Schumann, L., & Stock, W. G. (2014). The information service evaluation (ISE) model. *Webology*, *11*(1), 1–20.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model : four longitudinal field studies. *Management Science*, *46*(2), 186–204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly*, *27*(3), 425–478.

Yang, H.-H. (2013). Green urban public bikes rental system: A case study of Taipei

YouBike. *Advanced Materials Research*, *723*, 968–975.

Zhang, L., Zhang, J., Duan, Z. Y., & Bryde, D. (2015). Sustainable bike-sharing systems: Characteristics and commonalities across cases in urban China. *Journal of Cleaner Production*, *97*, 124–133.

APPENDIX: QUESTIONS

Appendix: Questions

Dimension 1:

Ease of Use:

- Logistical Proposal1: 'Sometimes my target *Bicing* bike station is full and I cannot return the *Bicing* bike' and 'Sometimes a *Bicing* Bike station I am at does not have any *Bicing* bikes'
- Logistical Proposal2: 'There are enough *Bicing* bike stations in Barcelona'
- Technical Functionality1: 'The card system is easy to use'
- Technical Functionality2: 'The card system does operate without any technical problems'

Usefulness:

- Rejection of Public Transport: 'Since the implementation of it I started to use bicycles more often than other transport possibilities'
- Rejection of own/a bike: 'Since I am using it, I do not need an/my own bike anymore'

Trust:

- 'I feel that my credit card and bank information are safe while using it'

Dimension 2:

Use:

- 'I am using the service'

Impact:

- City Performance: 'It contributes to the sustainable/green-minded development of Barcelona’

- User Performance: ‘Since I am using it I feel more green-minded’

Diffusion:

- ‘I would recommend it to my friends/family ‘and ‘I would recommend such a project to other cities’

Dimension 3:

Satisfaction:

- ‘I am satisfied with it’

Need:

- ‘It is needed’