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Motivators and barriers for shared bicycle use in 'starter' cycling cities: Evidence from BSS user surveys in three Southern European island cities

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Abstract

Bicycle sharing systems (BSS) have the potential to contribute to the creation of a cycling culture, by normalizing cycling and providing access to bicycles. This research looks at the use of BSS in 'starter' cycling cities, where modal share of cycling thus far is low and there is only limited cycling infrastructure. Surveys with users of the BSS in Limassol, Las Palmas de Gran Canaria and Malta shed light on "who" uses the BSS and "why". Through descriptive statistics and correlation analysis, the influence of individual, social environment and physical environment factors on shared bicycle use is analysed, looking at differences between frequent and infrequent BSS users, to get a better understanding of the motivators and barriers that influence BSS use. Frequent BSS use is positively associated with frequent use of other 'alternative' transport modes, such as public transport use, as well as with shorter distances from respondents' residence and most frequent destinations to the nearest BSS station. Higher perceived safety of cycling was also associated with more frequent BSS use, as did a positive social norm, including support from friends and family, respect from other road users, and feeling that cycling is an accepted form of transport, confirming the importance of such factors in building a cycling culture.

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Keywords: bicycle sharing; cycling; shared mobility; travel behaviour; correlation analysis; islands

1. Introduction

In the past decade bicycle sharing systems (BSS) have evolved from a fringe phenomenon to a commonplace feature in the mobility mix of many cities, providing an easy, flexible and low-carbon mode of transport. In 'starter' cycling cities,

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characterized by a low cycling modal share and limited cycling infrastructure (Félix et al., 2019), BSS have the potential to contribute to create a more cycling-friendly culture, by providing access to bicycles and by increasing the normality of cycling (Nikitas, 2018). In this research, motivators and barriers for BSS use were investigated in three cities on Southern European islands, where the promotion of cycling as a mode of transport has just started: Limassol (Cyprus), Las Palmas de Gran Canaria (Canary Islands) and the Valletta conurbation (Malta).

A question put forward in the literature, and one that is specifically relevant in cities with a minimal modal share of cycling and a budding bicycle sharing system, is "who uses bicycle sharing systems and why?" (Clark and Curl, 2016; Fishman, 2016). Mateo-Babiano et al. (2016) suggested surveying BSS users to investigate the impact of the built and natural environment on their BSS use. Research has shown that the provision of safe cycling infrastructure is one of the main determinants for more cycling and BSS use (Médard de Chardon et al., 2017). This research aims to understand who are the users of BSS in Southern European island cities and what are their motivations and barriers for using the BSS. Conducting surveys is one of the key ways to characterize BSS users and understand the motivators and barriers explaining their use of shared bicycles, and has been used in studies in e.g. Dublin (Murphy & Usher, 2015), Seville (Castillo-Manzano et al., 2015), and Brisbane and Melbourne (Fishman et al., 2014). This study contributes to the research field by providing a better understanding of BSS users in 'starter' cycling cities, their socio-economic characteristics, their motivations for using the BSS as well as the barriers they encounter, and how their BSS use is influenced by their social environment and the (perceived and actual) physical environment.

2. Literature review

Bicycle sharing systems (BSS), a mobility innovation providing public shared bicycles in cities, have become widespread in the past two decades, with almost 3,000 active systems in 2020 (Galatoulas et al., 2020). BSS users can be divided into two market segments: registered members who obtain a subscription on a monthly, semester or yearly basis, and casual users, who pay for a short term (e.g. per day, or up to a week) or on a pay-as-you-go basis (Jain et al., 2018). The pricing structure of BSS encourages short journeys; in most BSS the flat fee interval (FFI), or free rental time for subscribed users, is 30 minutes (Bordagaray et al., 2016). Despite the premise of being accessible to (almost) all, evidence from a number of different cities show that bicycle sharing users tend to be predominantly white, male, with relatively high income and education, and engaged in full-time or part-time work (Fishman, 2016; Médard de Chardon et al., 2017). BSS is used for a range of different purposes: for commuting (by professionals, students to travel to their place of work or study), for utilitarian purposes (by residents running errands), for leisure (for fun or exercise) and for sightseeing and recreational purposes (by tourists and visitors) (O'Brien et al., 2014). Subscription members most commonly use BSS for commuting purposes, whereas casual users are more likely to be leisure users or tourists, visiting points of interest, the city centre, or leisure areas such as parks and beaches (Fishman, 2016).

BSS have the potential to increase cycling uptake, and have been introduced to promote cycling in cities around the world, including in 'starter' cycling cities with a low cycling modal share and limited cycling culture. In Paris cycling increased by 70% after the launch of the BSS (Shaheen et al., 2010). Eight months after the introduction of the BSS scheme at the University of Valencia, cycling as a mode of transport rose from 6.9% to 11% among students participating in a longitudinal survey, a statistically significant increase (Molina-García et al., 2013). In Seville, within 3 years of implementation of the BSS in 2007, cycling modal share had risen to 6.6% of total journeys, a 5x increase compared to the level when the system was introduced (Castillo-Manzano & Sanchez-Braza, 2013). Evidence from surveys with BSS users in Washington DC (Buck et al., 2013) and Dublin, Ireland (Ó Tuama, 2015) confirms that BSS use can increase overall cycling modal share by encouraging new segments of society to cycle.

Common barriers to cycling include the lack of safe cycling infrastructure, road safety concerns, too long distances, hilliness and fear of arriving at a destination sweaty, and specifically for BSS, docking stations not being close enough to home and destinations (Félix et al., 2019; Fishman et al., 2014; Iwińska, et al., 2018). The main barrier identified for current and potential cyclists in 'starter' cycling cities are issues related to actual and perceived road safety and a lack of a safe cycling network, as evidenced by findings from several cities in Southern Europe: in Lisbon, Portugal (Félix et al., 2019), in Larnaca, Cyprus (Nikolaou et al., 2020), and in Drama (Nikitas, 2018) and Rethymno, Greece (Bakogiannis et al., 2019). Positive motivating factors for cycling include perceived health and environmental benefits, time and money savings, as well as access to the required facilities, i.e. access to a bicycle, parking facilities at home and destinations, showers at destinations (Félix et al., 2019). A positive social norm around cycling is also important, both in terms of the subjective

social norm - friends' and family's encouragement and support of cycling and the general attitude to cycling in a country – as well as the descriptive social norm – seeing the behaviour modelled by others, which can increase the willingness and confidence to cycle (Iwińska et al., 2018). To study the influence of independent variables on the likelihood of using BSS, Bachand-Marleau et al. (2012) constructed a binary logistic regression model, and found socio-economic characteristics, transport habits, and spatial characteristics (such as proximity of BSS stations to home and work locations) to be significant explanatory variables.

3. Case studies

The selected case study cities, Limassol (Cyprus), Las Palmas de Gran Canaria (Canary Islands) and the conurbation around Valletta (Malta), can be classified as 'starter' cycling cities. At the time of this study, they had a low cycling modal share (<1%), and a high car dependence. There is some promotion of alternative modes of transport in all three case studies, including the promotion of cycling; all three cities have seen the introduction of a bicycle sharing system and are in the early stages of the creation of bicycle infrastructure and implementation of cycling policies. The three case studies share other similarities as medium-sized coastal cities with comparable population sizes, historic centres and strong port-city relations, and being tourist destinations catering for visitors in addition to their resident population (Maas et al., 2021). The BSS in the three cities are all dock-based systems with (predominantly) regular bicycles. Table 1 provides an overview of the main characteristics of the BSS in the three case study cities.

Table 1. Overview of the characteristics of the BSS in the three case study cities (adapted from Maas et al., 2021)

	Limassol (LIM)	**Las Palmas de Gran Canaria (LPA)**	**Malta (MAL)**
BSS	Nextbike Cyprus	Sítycleta	Nextbike Malta
Operator type	Private operator	Municipal company	Private operator
Year introduced	2012	2018	2016
Number of bicycles and stations (in 2019)	170 bicycles, 23 stations	375 bicycles, 37 stations	360 bicycles, 60 stations
Registered users (in 2019)	~24,000	~22,000	~11,000
Subscription membership	€120/year	€40/year	€80/year
(Free rental time)	(120 minutes/day)	(30 minutes/trip)	(30 minutes/trip)
Pay-as-you-go fee	€2	€1.50	€1.50
(FFI: Flat fee interval)	(FFI 60 minutes)	(FFI 30 minutes)	(FFI 30 minutes)

4. Methodology

Data was collected through BSS user surveys to understand "who" the BSS users are, and "why" they use the BSS; to assess how intra- and inter-personal factors, such as socio-demographic characteristics, personal attitudes and perceptions, and the influence of their peers and wider social norms influence their use of the BSS. The BSS user survey was distributed as a self-administered revealed preference survey with a cross-sectional design, containing three sections: 1) demographic and socio-economic characteristics; 2) mobility practices and travel habits; and 3) attitudes and perceptions. Survey responses were collected through intercept surveys at BSS stations and by sharing the survey online. The survey questions were primarily closed-ended questions, which allowed for easy understanding and a quick progression through the survey, including binary yes/no questions, multiple choice questions, and questions scored on a Likert scale (Bryman, 2016).

In total, 140 surveys were collected in Limassol, 491 surveys in Las Palmas de Gran Canaria and 128 surveys in Malta. The margin of error, based on the active population of BSS users, obtained from a year of trip data from the BSS operators, was calculated to be 8.1% in Limassol, 4.4% in Las Palmas de Gran Canaria and 8.5% in Malta at a confidence level of 95%. For the aggregated analysis, the total of 759 surveys correspond to a margin of error of 3.5% at the same confidence level. During a 2 to 3-week fieldwork period in each of the case study sites (in Limassol in May 2019, Las Palmas de Gran Canaria in July 2019, Malta in September 2019), BSS users were approached in person at BSS stations, introduced to the research, and asked to fill in the survey on-site, using a tablet to access the web survey, or at a later stage, following a web link. The intercept survey approach was complemented with additional means to reach out to BSS users to take part in the survey online. In the case study cities, in discussion and collaboration with the BSS operators, different approaches were used to share the survey online with their users, via social media, the operators' websites and newsletters.

Descriptive statistics of the survey results were used to get an understanding of the "who" and the "why" of BSS use, using the frequency distribution of nominal and ordinal variables such as gender, education, and income to characterize the BSS users, and providing insight in the main motivators and barriers affecting BSS use and cycling. Through correlation analysis, the influence of individual, social environment and (perceived and actual) physical environment factors on the binary dependent variable 'BSS use' ('frequent' or 'infrequent') was investigated. Barbour et al. (2019) divided shared bicycle users into frequent and infrequent users depending on whether they used the BSS more or less often than once a month, whereas Bakogiannis et al. (2019) used the 'at least weekly' use as the cut-off point. In this analysis, the dependent variable 'frequency of BSS use' (an ordinal five-point Likert scale variable) was re-coded to a binary variable, including 'frequent' users, who use the BSS at least once every two weeks, and 'infrequent' users, who use the BSS less often than that. Factors included as independent variables include individual factors such as age, income and personal attitudes and habits, social environment factors, such as social subjective and descriptive norms, and (perceived and actual) physical environment factors, such as the perception of the influence of safe cycling infrastructure, the perceived effect of distance, weather and hilliness, and attitudes towards cycling in different road environments. Finally, the survey responses from the three case study cities were aggregated to draw generic conclusions as to which factors are encouraging or discouraging BSS use in these cities, and potentially in other 'starter' cycling cities with a similar context. As the number of respondents per case study city varied quite widely, two weighting adjustments were applied on the dataset in the analysis, to ensure the results are robust and representative of the aggregated datasets, and not dominated by the results from one city. The first weighting criterion was based on the proportion of the active BSS users in the city as a percentage of the total of the three case study cities. The second weighting criterion was based on equal representation of the three case study cities; a contribution of a third each to the total.

5. Results

5.1. Descriptive statistics

While respondents to the BSS user survey in Las Palmas de Gran Canaria and Malta are predominantly male (around 60% of respondents); in Limassol there is an almost even split of male and female users. In line with findings from the literature (e.g. Murphy & Usher, 2015), the majority of BSS users are between 18-24 and 25-34 years of age in Limassol and Malta, whereas in Las Palmas de Gran Canaria users are found from a wider age bracket, with more middle-aged users and less users in the youngest age category (18-24). In Las Palmas de Gran Canaria, the vast majority of respondents are native inhabitants (85%), whereas in Limassol (53%) and Malta (48%) that figure is much lower. However, the majority of these respondents are permanent residents of the cities (and to a lesser extent temporary residents), indicating that they primarily represent foreign residents, not visitors to the cities. In terms of education level, the BSS users in all three cities are generally highly educated, in line with findings from the literature.

The frequency of shared bicycle use is higher in Las Palmas de Gran Canaria than in Limassol and Malta. In Las Palmas de Gran Canaria, 62% of respondents use the BSS at least once every 2 weeks, versus 38% of respondents in Limassol and 45% in Malta. To understand the modal shift as a result of BSS use, respondents were asked what mode of transport they used to use for their most frequent BSS trip. The dominant category across the three cities is a shift from walking: 43% in Limassol, 31% in Las Palmas de Gran Canaria and 34% in Malta. Compared to walking, BSS use provides increased speed and convenience. The shift from the private car – primarily as drivers, only a small percentage as passengers – is 21% in Limassol, 20% in Las Palmas de Gran Canaria and 17% in Malta. In the case of modal shift from private car use, BSS use contributes to emission reductions and reduced air pollution, as well as an increase in physical activity and health benefits.

When asked about what motivates respondents to use the BSS, the top three motivating factors are consistent among the three cities: 'health', 'environmentally friendliness' and 'fun'. In Las Palmas de Gran Canaria 'convenience' and in Malta 'convenience' and 'time-saving' are also important motivating factors for the BSS users. The latter two factors are identified as the strongest motivating factors in other BSS research, and are further associated with BSS use for transport (Fishman, 2016). The importance of road safety and a safe cycling network is evident from the results for both encouraging and discouraging factors. The provision of 'more cycle lanes or paths' received the strongest positive response in Limassol and Malta as a factor that would encourage more cycling and BSS use, whereas in Las Palmas de Gran Canaria, the need for 'greater cycling safety awareness' scored the highest. Respondents in all three cities feel most safe on segregated bicycle

paths and least safe cycling on the road without cycling infrastructure, underlining the universal importance of safe cycling infrastructure on the decision to cycle.

5.2 Correlation analysis

Table 2 presents the results from the correlation analysis, using Spearman's correlation test to determine the strength and direction of the association, where a relationship between the dependent variable and independent variable was confirmed through a Chi-Square test. Only the factors that showed associations in all three cities are shown, to highlight the factors in common. The use of public transport and taxi as modes of transport, a shorter distance to the users' residence and most frequent destination, motivating factors such as money-saving and convenience, and the perceived safety while cycling on the road showed significant associations with the frequency of BSS use in all three cities.

Table 2. Correlation analysis: significant associations with frequency of BSS use in all three cities (LIM/LPA/MAL)

Dependent variable	**Definition**	**Spearman's correlation coefficients [b]**		
'Use_bikeshare_bin'	Frequency of use of BSS (binary)	**LIM**	**LPA**	**MAL**
Independent variables	**Definition [a]**	*(n=140)*	*(n=491)*	*(n=128)*
'Use_PT'	Frequency of use of public transport	0.212**	0.132***	0.294***
'Use_taxi'	Frequency of use of taxi	0.292***	0.137***	0.274***
'Dist_home'	Walking distance from residence to nearest BSS station	-0.210**	-0.134***	-0.333***
'Dist_dest'	Walking distance to frequent destination from nearest BSS station	-0.279***	-0.231***	-0.265***
'Mot_money'	Money-saving as a motivating factor	0.171**	0.260***	0.336***
'Mot_conv'	Convenience as a motivating factor	0.180**	0.258***	0.229***
'Safe_road'	Perceived safety on the road (in mixed traffic)	0.255***	0.136***	0.221**

*Notes: [a]: all variables are on an ordinal scale; [b]: - significant at ** p <0.05; *** p <0.01 level*

5.3 Aggregated analysis

The survey responses from the three case study cities were aggregated to draw generic conclusions as to which factors are encouraging or discouraging BSS use in these cities, and potentially in other 'starter' cycling cities with a similar context. The association between the dependent variable and nominal or binary variables was estimated through a Chi-Square test, whereas the association with ordinal independent variables was analysed through a Kruskal-Wallis test. Significant associations are presented in Table 3. The majority of demographic and socio-economic characteristics, such as gender, age, education, occupation and income, did not show significant differences between frequent and infrequent BSS users. Socio-economic factors that did show an association were household size, residency status and car ownership. Frequent BSS use is associated with respondents living in a 1-person household, rather than those in larger households. Temporary residents and visitors for work/education were more frequent BSS users, when compared to permanent residents and tourists. Frequent BSS use is associated with respondents who do not own a car. Distance to respondents' residence and most frequent destination again came out as important factors, with more frequent BSS use where distances to the nearest BSS station are shorter. In terms of travel habits and mobility practices, frequent BSS use is positively associated with frequent use of other 'alternative' transport modes (other than the private car; e.g. walking, public transport, taxi use). Frequent BSS use is mainly associated with 'commuter-type' motivating factors, such as money-saving, convenience and time-saving. Satisfaction with the BSS (the use and price of the system, the comfort of the bicycles and locations of the stations) also shows strong associations with frequent BSS use, as did higher perceived safety of cycling, with most frequent BSS users using dedicated cycling infrastructure (bicycle paths or lanes). Weather factors, including hot and sunny conditions, as well as rainy and windy weather, both showed a positive association with more frequent BSS use, suggesting that weather conditions are not negatively affecting BSS use of frequent users. A positive social norm, in terms of support from friends and family, respect from other road users, and feeling that cycling is an accepted form of transport, showed positive associations with BSS use, confirming the importance of such factors in building a cycling culture.

Table 3. Aggregated analysis: significant associations with frequency of BSS use

Dependent variable	**Definition (scale)**	
'Use_bikeshare_bin'	Frequency of use of BSS (binary)	
Independent variables	**Definition (scale)**	***p*-value**
'Household'	Household size (nominal)	0.036 [a]
'Residency'	Resident or visitor of city of BSS (nominal)	0.047 [a]
'Own_car'	Private car ownership (binary)	0.001
'Dist_home'	Walking distance from residence to nearest BSS station (ordinal)	0.000
'Dist_dest'	Walking distance to frequent destination from nearest BSS station (ordinal)	0.000
'Use_walking'	Frequency of walking >5 minutes (ordinal)	0.000
'Use_PT'	Frequency of use of public transport	0.000
'Use_taxi'	Frequency of use of taxi	0.000
'Mot_money'	Money-saving as a motivating factor	0.000
'Mot_conv'	Convenience as a motivating factor	0.000
'Mot_time'	Time-saving as a motivating factor	0.000
'Sat_price'	Satisfaction with the pricing of the BSS (ordinal)	0.000
'Sat_comf'	Satisfaction with comfort of the bicycles (ordinal)	0.000
'Sat_loc'	Satisfaction with locations of the stations (ordinal)	0.000
'Safe_lane'	Perceived safety on a bicycle lane on the road (ordinal)	0.000
'Safe_road'	Perceived safety on the road, without cycling infrastructure (ordinal)	0.000
'Cycle_sun'	Attitude towards cycling when it is hot and sunny (ordinal)	0.001
'Cycle_rain'	Attitude towards cycling when it is rainy and windy (ordinal)	0.004
'Friends'	Perception of support of cycling behaviour by friends and family (ordinal)	0.000
'Road_users'	Perception of respect of other road users towards cyclists (ordinal)	0.001
'Cycle_accept'	Perception of cycling as an accepted form of transport in city (ordinal)	0.000

Note: [a] *only significant at p <0.05 in analysis of unweighted dataset*

6. Discussion

The top three motivating factors for BSS users in the three case study cities were 'health', 'environmentally friendly' and 'fun', confirming the positive association between BSS use and a positive attitude towards environment and sustainability (Yin et al., 2018) and health reasons as a motivating factor (Félix et al., 2019). 'Convenience' and 'saving money' emerged as the two factors most strongly correlated with BSS use in all three cities, in line with findings from other BSS research, particularly in relation to commuting cycling (Fishman, 2016). The overall satisfaction with the BSS in all three case study cities was high. Satisfaction with the operation of the BSS, a user-centric design, and a high level of service to users have been identified as important contributors to BSS usage and scheme longevity (Nikitas, 2019). All three case studies cities so far have a low cycling model share and a high rate of motorization and high car modal share. In cities with a low cycling modal share, the dominant habits and customs tend to deter cycling (Pucher, Dill, & Handy, 2010), e.g. as a result of the lack of adequate infrastructure (Félix et al., 2019), the inability to imagine oneself as a cyclist, or the perception of cycling as something from the past, as something for poor people, or only as a sport or leisure activity (Aldred & Jungnickel, 2014). In the aggregated analysis of the survey responses from the three case study cities, a positive social norm, in terms of support from friends and family, respect from other road users, and feeling that cycling is an accepted form of transport, showed positive associations with BSS use, confirming the importance of such factors in building a cycling culture. The normality of cycling, both in terms of it being an accepted form of transport by an individual, as well as by wider society, is an important driver for cycling behaviour (Goodman, et al., 2014). BSS can encourage different societal groups to start cycling, through social contagion (Schoner et al., 2016). Analysis of BSS use in Seville and Dublin showed that the majority of respondents to a survey about their BSS use indicated that they had not been cycling before starting using the BSS (Castillo-Manzano et al., 2015; Murphy & Usher, 2015). However, as put forward by Ricci (2015) in her review of BSS research, for BSS to contribute to an increase in cycling modal share, complementary pro-cycling measures and wider support to sustainable mobility are needed. In addition to the creation of safe and attractive places (e.g. safe cycling infrastructure) and the physical provision of the required tools (e.g. access to a bicycle and parking, as provided by the BSS), there is a need for educational and motivational programs to encourage the behaviour, as well as for mass media campaigns and community organization to change social norms and culture (Sallis et al., 2006).

In accordance with findings from the literature, the strongest barriers identified are related to busy roads and a lack of road safety (Bakogiannis et al., 2019; Félix et al., 2019), as well as too large distances between BSS stations and users' residence or frequent destinations (Félix et al., 2019; Iwińska et al., 2018). The creation of dedicated cycling infrastructure on arterial roads, reduction of speed limits on residential and rural roads, and awareness raising among all road users are proven strategies to improve road safety for cyclists and promote cycling (Heinen et al., 2010; Handy et al., 2014). To increase the coverage and connectivity of the BSS, the density of stations can be increased by creating more, small-sized, stations, particularly in areas with many points-of-interest (POI), so as to provide more connections between potential origins and destinations (Faghih-Imani et al., 2014).

While user surveys are essential to understand user experience and behaviour, self-reported data obtained through voluntary-based survey responses is subject to a number of possible biases, such as social desirability bias, sampling bias and participation bias. To minimize social desirability bias, the survey was kept anonymous. In an effort to address sampling and participation bias and increase the response rate, the survey was shared through different channels and locations (i.e. on social media, through email newsletter, in-person, through freebie left on the bicycles), to try and reach different types of users: casual and subscribed users, frequent and occasional users. However, a certain level of bias is still expected in any self-report survey study (Bachand-Marleau et al.,2012; Bryman, 2016).

7. Conclusion

Data was collected through BSS user surveys to understand "who" the BSS users are, and "why" they use the BSS, to get a better understanding of the motivators and barriers that influence BSS use in three 'starter' cycling cities: Limassol, Las Palmas de Gran Canaria and Malta. Results from the correlation analysis highlight the main factors influencing BSS use in these 'starter' cycling cities: (i) more frequent use of public transport and taxi as alternative modes of transport, (ii) shorter distances to the respondents' residence and most frequent destination, (iii) money-saving and convenience as motivating factors, (iv) the perceived safety while cycling on the road. The aggregated analysis further showed that while most demographic and socio-economic characteristics did not show a significant association with frequent BSS use, there was a positive relationship with users living in a single household, with temporary residents and visitors for work/education and users who do not own a car. Satisfaction with the BSS also showed a strong positive association with BSS use. Both hot and sunny weather, as well as rainy and windy conditions were positively associated with frequent BSS use, indicating that weather conditions do not negatively affect the BSS use of frequent users in these cities. Perceptions of a positive social norm around cycling showed a positive relationship with frequent BSS use, confirming the importance of such factors in building a cycling culture.

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