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“Green, but not as green as that”: An analysis of a Brazilian bike-sharing system

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ABSTRACT

According to academics and urban planners, the smart city concept favors technological products and solutions over end users and their adherence to a smart city proposal. The smart city concept is also considered in the cities of Latin America, one of the most urbanized and unequal regions of the world. Smart city implementation in such contexts can provide lessons on urban innovation when resources are scarce and the environments are volatile. Thus, it is possible to verify that one of the most implemented solutions to diminish the increasing urban congestion and its effects on citizens' quality of life is related to smart urban mobility. This paper sought to evaluate the perception of bike-sharing users in a smart city and analyze the main motivations for using this system. The research analyzed the bike-sharing system of Passo Fundo, a medium-sized city in southern Brazil. Interviews with 526 residents identified three main motivations for using the bike-sharing system: (i) health and the environment, (ii) being social influencer, and (iii) the cyclist lifestyle. The respondents' overall perception revealed their low satisfaction with the bike-sharing system and with the overall conditions for cycling. This finding calls for a better understanding of the planning and management of smart cities in conjunction with citizen's perception and their effects on the city smartness. The research provides contributions regarding understanding the interconnected aspects of bike-sharing systems in the developing countries context. From a smart city perspective, we conclude that success within the domain of smart mobility can be achieved by observing the three factors revealed by the analysis. According to our results, meeting these criteria through public policies would increase bike-sharing, creating a green behavior trend.

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1. Introduction

Urbanization is a growing concern, because 54% of the world's population is concentrated in urban areas, a proportion expected to increase to 66% by 2050 (UNEP, 2014). This accelerated growth makes urban centers crowded, complex, and cluttered places (Johnson, 2008; Dirks et al., 2010) and generates several problems, for example, resource scarcity, air pollution, decreased human health decreased, traffic, inappropriate infrastructure (Marceau, 2008; Vasseur, 2010). According to the Energy International Agency, the CO_2 emission from urban transportation represents 23% of world fossil fuel combustion (IEA, 2015). In this sense, to guarantee livable conditions in the scenario of urban population growth, the smart city concept has been studied and applied, encouraging many cities around the world to become more efficient, intelligent, and sustainable than ever (Chourabi et al., 2012).

Smart cities attempt to accomplish these aims and more. Smart cities are defined by the application of smart methods to build livable, sustainable cities (Chourabi et al., 2012). In this context, smart urban mobility is a main topic because it integrates social capital, traditional transportation, and modern information and communication technology (ICT) infrastructure to provide sustainable economic development and a high quality of life (Vezzoli and Ceschin, 2008; Caragliu et al., 2011). The concept of smart mobility is based on reducing the inefficient use of private vehicles and increasing environmentally sustainable transportation (Zhang

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et al., 2015).

Public bike-sharing systems could be operated by the government or private companies and a component added to the public transportation systems, along with other means of transportation, such as buses, taxis, and the subway (Yang and Long, 2016). Bike-sharing systems tend to reduce the automobile dependency in urban centers. Although the number of studies on smart mobility and bike-sharing systems have increased, we observed a gap in the literature regarding understanding the motivations of bike-sharing systems' users (Fishman et al., 2013; Zhang et al., 2015).

Sustainable mobility requires adopting sustainable transportation and decreasing the number of private automobiles (Yin et al., 2016); because of this context, public bike-sharing services are becoming increasingly popular and receiving increasing attention from researchers, policymakers, and social marketers (Kaltenbrunner et al., 2010; Fishman et al., 2013). These sharing systems provide bicycles for short-term trips: from one station to another (Fishman et al., 2013).

The increasing expansion of bike-sharing systems worldwide and its adaptability to various situations are attractive indicators (Midgley, 2011). Evidence of success were clearly observed in terms of shared bikes' utilization; however, bikes' long-term maintenance depends on various key factors, for example, quality cycle infrastructure, appropriate bike-line installations, bike maintenance, system accessibility, demographical and operational conditions, public attitude toward cycling, weather and topographical conditions, terminals, and technological platform security (Curran, 2008).

The bike-sharing system is a typical means of transportation in medium-sized cities; because of its contribution to traffic security (Pojani and Stead, 2015), the bike-sharing system demands constant investment and support for users (Dimitriou and Gakenheimer, 2011). After 2008, the use of shared bikes overcame the growth of all other urban forms of transportation (Midgley, 2011).

This paper aims to fulfill the gaps in the literature regarding bike-sharing systems in emergent countries. The goal is to analyze the motivations to use shared bikes in a context of an emerged country. To analyze the motivations and identify the system acceptance, the study method includes a survey to obtain information from users and nonusers in the city of Passo Fundo, in the south of Brazil.

Section 2 presents the theoretical references regarding smart cities, namely, smart mobility and bike-sharing systems. In section three, the methodological procedures are discussed. In section four, the results are presented and discussed. Finally, we conclude by highlighting the study's theoretical and applied contributions.

2. Smart city

Smart cities are defined as cities in which the human and social capital investments, combined with transportation and telecommunication infrastructure, generate sustainable and economic development (Caragliu et al., 2011) beyond a high quality of life (Ballas, 2013). In this line of research, other city categories have been observed in politic agenda: sustainable cities, green cities, eco-cities, low-carbon cities, and other nomenclatures. Despite conceptual differences, each category is associated with a degree of ICT infrastructure (Caragliu et al., 2011; Capdevila and Zarlenga, 2015).

However, in practice, the use of terms is usually preformed indistinctly, which turns the concept fuzzy, and not always consistent among policy makers, planners, and developers (Chourabi et al., 2012; Papa et al., 2013; Albino et al., 2015). The smart cities are recognized as diverse urban labeling (Johnson, 2008) that focuses on different topics, such as consciousness, flexibility, transformation, synergy, individuality, self-determinism, and strategic behavior (Giffinger et al., 2007).

A smart city guarantees that the urban services do not decline in the long-term (Cunha et al., 2016), that is, related to the comprehension of its city, its goals and identity, and its stakeholders and priorities while identifying the attributes that fit its singularity (Al-Nasrawi et al., 2015). The increasing number of studies regarding smart cities has contributed distinct definitions to the term "smart cities" (Table 1).

ICTs are changing cities' policies regarding planning and growth. In this manner, smart cities base their strategies on the use of these ICTs to transform the city's infrastructure and services (e.g., environment, mobility, economy) (Bakici et al., 2013). Smart cities represent a conceptual model of urban development based on the use of human resources and collective and technological capitals to develop urban agglomerations (Angelidou, 2015).

Smart city initiatives focus on using ICTs to transform aspects of life in a meaningful and fundamental manner by exploiting the resources of a digital, innovative, and collaborative city (Komninos and Sefertzi, 2009). Therefore, a digital city is not necessarily smart, whereas a smart city always comprises digital elements (Allwinkle and Cruickshank, 2011; Dutta, 2011).

Smart cities must be created based on six intelligent dimensions (Giffinger et al., 2007; Lee et al., 2013), because they must focus beyond the exclusive use of ICTs (Hollands, 2008). Within this framework, there must be pillars of a smart economy, smart mobility, a smart environment, smart people, a smart life, and smart governance (Lee et al., 2013). These six dimensions are based on theories of transportation and the ICT economy, regional competitiveness, natural resources, human and social capital, quality of life, and citizen participation in city governance (Lombardi et al., 2012).

The pillar of smart mobility should increase sustainability and be as inclusive and healthy as possible (European Union, 2013). Among the dimensions of smart mobility are a sustainable public transportation system (energy-efficient and affordable), easy access to all parts of the city, and conditions favorable to moving in and around an area with a bicycle (European Union, 2013). The ability to ensure smart mobility in cities is a key factor for sustainable economic growth (Venugopal, 2017).

2.1. Smart mobility

Urban mobility is a major challenge for cities, due to the fast population growth and the search for new options for a sustainable transportation system (Van Audenhove et al., 2014; Benevolo et al., 2016). Therefore, smart mobility is one of the dimensions of intelligent city implementation and affects the other dimensions of the city, such as aspects of the citizens' quality of life (Nam and Pardo, 2011; Arena et al., 2013).

The mobility challenges are related to sustainability, and urgent drivers have been observed in the transportation sector due to the necessity to reduce carbon emissions, traffic, noise, and health problems related to air quality (Casey and Valovirta, 2016). These challenges are complex because less sustainable behaviors are difficult to change and perceived as normal and practical for all citizens (Rettie et al., 2012). The objectives related to smart mobility are grouped into six categories: (i): reducing pollution; (ii): reducing traffic congestion; (iii): increasing safety; (iv): reducing of noise pollution; (v): improving commute speed; and (vi): reducing transfer costs (Greco and Bencardino, 2014).

In addition, different approaches to the smart city, that is, the digital city, the green city, and the city of knowledge, must be used to make the mobility system intelligent and successful (Benevolo

Table 1
Smart city definitions.

Authors	Definition
Kanter and Litow (2009, p.2)	"A smarter city infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, recover rapidly from disasters, collect data to make better decisions and deploy resources effectively, and share data to enable collaboration across entities and domains."
Giffinger and Haindl (2009, p.708)	"A Smart City is a city built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens."
Nam and Pardo (2011, p.185)	"The connotation of as mart city represents city innovation in management and policy as well as technology. Since the unique context of each city shapes the technological, organizational and policy aspects of that city, a smart city can be considered a contextualized interplay among technological innovation, managerial and organizational innovation, and policy innovation."
Caragliu et al. (2011, p.70).	"A city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance."
Albino et al. (2015, p.11).	"The most common characteristics of smart city are: a city's networked infrastructure that enables political efficiency and social and cultural development. An emphasis on business-led urban development and creative activities for the promotion of urban growth. Social inclusion of various urban residents and social capital in urban development. The natural environment as a strategic component for the future."
Söderström et al. (2014, p.309)	"In quite general terms, smart city involves the creation of new relations between technology and society according to this view, urban infrastructures and everyday life in cities are optimized through technologies of information."

et al., 2016). This use is justified because digital cities can use ICTs and software with distinct intentions, such as optimizing traffic flow and public transportation routes (Mechant et al., 2012). Green cities are directly related to the environmental impact of transportation, one of the biggest emitters of pollution in cities (Zygiaris, 2013). Green cities are directly related to the cities of knowledge, because the intelligent behavior of the population is directly connected with the intelligence of transportation and the sharing of civic values (Nam and Pardo, 2011).

The primary focus of smart cities is the role of ICT infrastructure, and the primary focus of smart mobility is the role of human capital, social and relational capital, and environmental topics, which represent a critical impetus of urban growth (Lombardi et al., 2009). In this perspective, smart mobility is one of many aspects of smart cities (Sciullo and Occelli, 2013). Notably, smart mobility intends to help smart cities to reach their specific goals, reducing the city's environmental impact and improving citizens' quality of life (Benevolo et al., 2016). Therefore, an unsustainable mobility plan cannot be considered smart (Garau et al., 2016).

2.2. Bike-sharing systems

Bike-sharing emerged in Europe in the 1960s. Currently, four continents offer sharing systems: Europe, North America, South America, and Asia (Shaheen et al., 2010). The bike-sharing systems passed through three stages: (i) the free-bike system that started in Amsterdam, in 1965; (ii) the coin dispenser system that started in Copenhagen, Denmark, in 1995; and (iii) the ICTs-based system that emerged in France, in 1998 (Shaheen et al., 2010).

The growth and establishment of bike-sharing sharing programs has enabled cities to express concern about health problems, traffic congestion, and fossil fuel dependence. This context is associated with improvements in the capacity and accessibility of tracking, communication, and safety technologies, and has contributed to the growth of bike-sharing programs (Fishman et al., 2013). The main goal of introducing bicycle sharing is to promote cycling, increase mobility choices, improve air quality, and reduce traffic (Midgley, 2011).

Cities that adhere to smart urban mobility plans usually promote public transportation and restrict the use of cars, reducing traffic and providing a friendly environment for bike-sharing systems (Shaheen et al., 2010). Public bike-sharing has benefits, including a decrease in traffic and fuel use and an increase in mobility options and health benefits. Bicycles have played an important role in transportation policies and are a non-polluting, flexible, and economical vehicle that contributes to traffic reduction and improved health (Shaheen et al., 2010; Midgley, 2011, De Souza et al., 2014).

The introduction of smart technology into bike-sharing systems solved many of the problems initially identified, such as vandalism and bicycle theft (Midgley, 2009) and helped encourage casual and touristic use, due to a fast and easy registration system (Midgley, 2011).

However, to guarantee the success and increased participation of users in bike-sharing programs, it is necessary to identify the perception about the barriers regarding the use of bicycles as a means of transportation. The literature has revealed several barriers, such as travel time, perceived insecurity, intense traffic, absence of infrastructure, weather factors, and topography (De Sousa et al., 2014). Another important role in and key factor for a successful bike-sharing system is the availability of an extensive and continuous bicycle lane. Equally important is the combination of a favorable topography and weather (Midgley, 2009), and the guarantee of a bicycle free of charge and without ownership responsibilities, stimulating a healthy and environmentally friendly means of transportation (Shaheen et al., 2010).

3. Methods

3.1. Questionnaire design

To analyze the motivations and identify the factors of acceptance of a bike-sharing system in a medium-size city located in Brazil, two instruments were created: one for bike users and another for nonusers. These instruments were based on the studies of Brown et al. (2009).

The first instrument presented 11 questions about the respondents' motivations to use bikes from the "Passo Fundo *Vai de Bici*" program. The questions included the following topics: reduction of environmental pollution, collaborative traffic, life quality, economy, sustainability, life style, and the use of the bicycle as a mean of transport. The second questionnaire was created for nonusers of the sharing system to identify the motivation for not using the system. Ten questions were presented with options that addressed variables such as not knowing how to ride a bike, the absence of bike lanes, topographical barriers, the absence of bikes, inappropriate clothes, distance to stations, lifestyle, non-collaborative traffic, or weather. The instrument also contained nine questions about the reasons that could lead the respondent to use the bike-sharing system in the near future. We presented the respondents with a 5-point Likert scale, and the interviewers matched the one option that best fit with their perception. All items were measured using a 5-point Likert scale (1 = *strongly disagree*; 5 = *strongly agree*).

In both cases, the respondents answered the frequency of use of some means of transportation: walking, cycling using own bike, cycling using the bike-sharing system (*Passo Fundo Vai de Bici* Program), own car, public transportation, and motorcycle. Finally, users and nonusers answered 15 closed questions about socio-demographic data (i.e., sex, age, educational background, socio-economical level) and their perception of some aspects of the city. The decisions regarding the layout of the questionnaire and the final approval of the questionnaire were the responsibility of four researchers during the face-to-face meetings.

3.2. Survey procedures

The data collection was conducted in July and August 2017 and obtained through an online version (i.e., an online link to the questionnaire) or directly at the bike stations (i.e., a printed questionnaire). At each station, the researchers approached the cyclist or pedestrians randomly. The researchers asked for the voluntary collaboration of the interviewees, who were informed there were no correct or incorrect answers. All the respondents were informed about the anonymity of responses and that the responses would be treated as a whole and used for academic purposes. An average duration of 10 min was sufficient to complete the questionnaire.

The answers from the printed and online version were grouped in the same sheet and, subsequently, organized in the Statistical Package for the Social Sciences (SPSS) database. There were 526 respondents in this study (i.e., the minimum sample for unlimited population is 398 respondents), among these respondents were 266 users of the bike-sharing system (*Passo Fundo Vai de Bici*) and 260 nonusers. The snowball technique was used to guarantee the number of respondents: the researchers asked each respondent to send an email to another possible user or nonuser of the bike-sharing system.

3.3. Data analysis

Data were analyzed using descriptive statistics of respondents' profile, factor analysis for the motivation of users and nonusers Cronbach's alpha for factor reliability, and analysis of variance for sociodemographic variables (Hair et al., 2003). The researchers used the software SPSS, version 20 for Windows® for data analysis.

Descriptive and factorial analyses were used to summarize and reduce the data (Hair et al., 2003). Factorial analysis is a multivariate technique of interdependence in which all variables are simultaneously considered, each related to the other, to study the interrelation between them and reduce the data (Hair et al., 2003). This type of analysis recognized latent relationships and combined study variables (Hair et al., 2003). The factorial analysis allowed the identification of the core factors for bike-sharing system adoption or avoiding. Finally, the analysis of variance (ANOVA) was used to verify the difference between the means of two or more groups (Hair et al., 2003).

4. Analysis and result discussion

4.1. Bike-sharing system in Passo Fundo

Sustainable behavior related to urban mobility (Zhang et al., 2015) is playing a key role in the movement toward a sustainable economy and society (Vitell, 2015). Sustainable transportation planning emphasizes the long-term development of a city and involves the population and other stakeholders in the search for effective means to integrate product development, service delivery, and innovation into human transportation business models (May, 2013; Zhang et al., 2015).

The city of Passo Fundo started its sustainable mobility program in 2016 to promote health and sustainability. The estimated population of Passo Fundo is 198,799 inhabitants, with a territorial area of 783,421 km^2 and a population density of 235.92 hab/km^2 (IBGE, 2017). Passo Fundo fits the population size recommendation for bike-sharing programs, that is, a population greater than 200,000 inhabitants (Bührmann, 2007).

The program consists of an automatic bicycle lending system, based on the sharing experience, in which the objective is to encourage the use of ecological, non-motorized, practical, clean, quiet, healthy, and environment-friendly transport. From this perspective, in the first half of 2017, approximately 49.708 tons of carbon dioxide (CO_2) were no longer emitted into the atmosphere (Passo Fundo City Hall, 2017).

The program has 110 bicycles (Fig. 1) available to the population in ten stations. The service is free and requires only the registration of the citizen in the project (http://pfvaidebici.mobhis.com.br/#cadastro). This system fulfills the principle of bike-sharing: individuals use the bicycles according to their needs and without the costs of their use (Shaheen et al., 2010).

The shared bicycles are used for small and medium displacements by the main roads of the city and to reduce the traffic from vehicles, especially in the center of the city. The average rental time is on average 43 min, and an average of 165 trips are taken per day. The highest peak of use occurs from 12:00 p.m. to 5:59 p.m., and of 48% of the bicycles are used in that period (Passo Fundo City Hall, 2017).

4.2. Identification and analysis of factors of bike-sharing system utilization

The descriptive analysis revealed that of the 266 respondents who use the bicycle sharing system, 53.8% are male. The users' age range for users was concentrated between 18 and 28 years (50.0%), and the predominant income was between R$2000.00 and R$4000.00 per month (31.2%). Of all the respondents, 51.1% were single and 63.9% had children. Regarding educational background, incomplete higher education (24.8%) predominated. The majority (78.9%) of the respondents intended to continue residing in the city for the next 5 years.

Considering the bike-sharing users who work in the city, when asked about the means of transportation they normally use to go to the workplace, 34.4% answered that they go by car, followed by users who go to work on foot (28.1%). By contrast, when asked about the means of transport they would like to use to go to work,

Fig. 1. Bicycles of the sharing program in the city of Passo Fundo (Brazil). Source: PMPF (2017).

the bicycle was the most cited, with 47.4% of intentions.

Users preferred cycling alone (44.7%) or in the company of family and boyfriends (31.2%); the majority of users approved of the station locations (82.3%). When questioned about what the respondents liked most about the city of Passo Fundo, the predominance of answers were the public squares (51.8%) and the quality of educational services (15.4%) (Table 1).

Concerning the 260 nonusers, 70.4% were female; the age range was from 18 to 28 years-old (36.9%); the monthly income was approximately between R$4000.00 and R$7000.00 (29.6%); 55.0% were married and had no children, which contrasted with the group of users (i.e., the majority were single and had kids); 88.8% developed their professional activities in Passo Fundo; 41.9% had an educational background at the post-graduation level; 54.4% use a car as their means of transportation to go to work, but 41.5% of them would prefer to go to their workplace on foot if they considered that option reasonable; 79.0% own their cars; and 85.0% intend to continue living in Passo Fundo for the next 5 years.

When the respondents were asked about what they liked the most in the city, 36.2% chose public squares, followed by quality of educational services (19.7%). These preferences are similar compared with the bike-sharing users (Table 2).

The users' sample data ($n = 266$) were submitted to factorial analysis using principal component of analysis, with varimax rotation and listwise treatment for missing values. The index of the Kaiser-Meyer-Olkin adequacy of the sample was 0.809, and the Bartlett's Test of Sphericity ($p < 0.01$) indicated the factorability of the data. The final model of factorial analysis resulted in ten variables. The bike use by the users is explained through three factors, with 57.13% of total variance explained.

The Cronbach's alpha to this scale was 0.758, which represents a satisfactory value for an exploratory study (Hair et al., 2003). This

Table 2
Characterization of the respondents (users and nonusers of shared bicycles).

Variable	Users		Nonusers	
	Frequency (%)	N	Frequency (%)	N
Sex				
Male	53.8	143	29.6	77
Female	46.2	123	70.4	183
Age				
18–28 years	50.0	133	36.9	96
29–38 years	25.9	69	35.7	93
39–48 years	15.7	42	16.5	43
Over 48 years	8.4	22	10.9	28
Family income				
Up to R$2000.00	28.9	77	13,1	34
Between R$2000.00 and R$4000.00	31.2	82	29,2	76
Between R$4001.00 and R$7000.00	20.7	56	29,6	77
Between R$7001.00 and R$10,000.00	7.9	21	13,8	36
Above R$10,000.00	11.3	30	14,2	37
Marital status				
Married/stable marriage	48.5	129	55.0	142
Single	51.1	136	43.7	114
Other	0.4	1	1.5	4
Have children				
Yes	63.9	170	45	117
No	36.1	96	55	143
Schooling				
Incomplete elementary school	4.5	12	0.8	2
Incomplete middle school	7.1	19	1.2	3
Complete high school	17.3	46	10.4	27
Incomplete higher school	24.8	66	23.8	62
Graduated	23.7	63	21.9	57
Postgraduate	22.6	60	41.9	109
How's going to work				
Car	34.4	91	54.4	141
On foot	28.1	75	18.3	48
Bus	18.1	48	17.4	45
Bicycle	9.0	24	0.8	2
Others	10.4	28	9.1	24
How I would like to go to work				
Bicycle	47.4	126	21.9	57
On foot	25.2	67	41.5	108
Car	22.6	60	30.0	78
Bus	2.3	6	3.1	8
Others	2.5	7	3.5	9
Who do you usually ride a bike with				
Alone	44.7	119	–	
Relatives	31.2	83	–	
Friends	24.1	64	–	
What do you like the most in the city?				
Squares	51.9	138	36.2	94
Schools	15.4	41	19.7	51
Stores	9.8	26	177	46
Health services	9.0	24	13.4	35
Others	13.9	37	13.0	34
Total	100	266	100	260

Table 3
Factorial results for the shared bicycles users.

Factor	Items	Loading	Mean	Standard deviation
Health and environment (0.68)[a]	Q3 – It is a less polluting means of transportation than the others.	0.778	4.69	0.77
	Q4 – I try to contribute to reducing traffic when using an alternative means of transportation.	0.610	4.41	0.91
	Q6 – I think it's healthy to ride a bike.	0.618	4.88	0.47
	Q7- The bicycle is a cheaper means of transportation than the other means of transportation.	0.678	4.69	0.61
Social influencer (0.62)[a]	Q8- I try to follow the practice of some developed countries, where the bicycle is used a lot.	0.758	4.13	0.99
	Q9 – Public transportation is unsatisfactory.	0.645	3.70	1.02
	Q10- I want to serve as an example for people who do not use the bicycle.	0.656	3.89	1.19
Cyclist lifestyle (0.54)[a]	Q5 – The bicycle is more agile compared with other means of transportation.	0.756	4.02	1.10
	Q11- The bicycle is my only means of individual transportation.	0.609	2.71	1.62
	Q12- Using a bike is part of my lifestyles and values.	0.659	3.91	1.14

[a] Cronbach's Alpha.

test indicates that the items in each construction dimension are adequate to evaluate the perception of bike users of the sharing program (Table 3).

The data expressed in Table 3 show the variables grouped in the factorial analysis and provide the perception of the users regarding the use of the bicycles of the sharing program. The most significant factor, "Health and environment," groups variables related to a sense of contribution to traffic, environment and health promotion. This group is formed by variables that express how citizens perceive the use of the bicycle as a means of transportation that is less polluting than the means of transportation. In addition, the bicycles contribute to alternative transit through healthy, cost-effective practices, because citizens use the bicycle according to need and without cost (Shaheen et al., 2010).

Each kilometer pedaled results in individual and social benefits because cycling is an "active" mode of transportation that provides substantial health benefits to individuals and, consequently, reduces costs to society (Meschik, 2012). Personal and social gains are strong predictors for choice and continuity of cycling (Bakker et al., 2017). Health outcomes through cycling include weight control and willpower, disease prevention (Brown et al., 2009), and external environmental outcomes such as decreased CO_2 emissions (Yang and Long, 2016). Similar findings were found in the study by Woodcock et al. (2009), where users attributed significant health gains to using shared bicycles and attributed significant reductions in CO_2 emissions to cycling instead of driving cars.

The second factor is "Social influencer," refers to mobility as a sustainable practice, and includes the variables related to the use of the bicycle in favor of sustainability. This group consists of questions related to the model of cycling compared with developed countries, dissatisfaction with public transportation offered, and the intention to serve as an example to other people who do not use the bicycle in their daily lives. Additionally, Social influencer is a relevant component for sustainable urban mobility and health promotion (Bakker et al., 2017). Social influencers are examples to others, encouraging the use of a bicycle as a factor related to self-presentation, which leads to an optimization of favorable social relations (O'Connor and Brown, 2007). The factor of social influence is directly related to the propensity of users to develop sustainable practices according to the representations of what is socially shared. Behaviors are based on the principle of conformity, that is, citizens practice what is considered normal and practiced by others, despite their awareness of unsustainability (Rettie et al., 2012).

Finally, the third factor, "Cyclist lifestyle" groups the elements that represent the bicycle as a way of life, which was considered a motivating factor in the literature (Fishman et al., 2014). Lifestyle is related to choices, particularly preferences; thus, the use of bicycles as a lifestyle is an option for individual behavior (Walker and Li, 2007). In similar situations (e.g., topography, weather), an individual who does not have cycling as a lifestyle will probably use another means of transportation. In this same group, there is also the variable "It is my only means of transportation," which may be a lifestyle choice or economic decision.

Considering the explained variance, we observe a balanced distribution between the three factors. The "Health and environment" factor explains 19.78% of the total variance, followed by "Social influencer" with 19.36% of variance explained, and "Cyclist lifestyle" with 17.99% of the variance explained.

ANOVA was used to identify statistical differences between the means of the two groups (users and nonusers of bicycles). The aim was to explore the explanatory possibilities of the behavior of the respondents regarding the motivation to use shared bicycles. In the group of users, there were statistically significant differences ($p < 0.05$) in the variables for sex, marital status, education background, working in Passo Fundo, and income (Table 4).

Table 4 shows that of the user group, the males are concerned with the environment and use the bicycle because it is a means of transportation that pollutes less than the other means of transportation. In this sense, a concern to encourage the adoption of more sustainable consumption practices is observed (Rettie et al., 2012).

The marital status of users also differs statistically ($p < 0.05$) because people who are single are more concerned with improving

Table 4
ANOVAs for shared bicycle users.

Variable	F	Sig.	Result
Sex	3.90	0.04	- Men consider the bicycle a means of transportation that pollutes less than the other means of transportation.
Marital status	5.09	0.00	- Single users contribute to reducing traffic when using alternative transportation.
Educational background	2.28	0.04	- Users with incomplete higher education seek to contribute to reducing traffic through alternative transportation.
	9.51	0.00	- Users with incomplete higher education have a bicycle as the sole means of transportation.
Working in Passo Fundo	9.42	0.00	- Workers from Passo Fundo want to contribute to reducing traffic when using the bicycle.
Income	2.28	0.02	- Users with incomes between R$2000.00 and R$4000.00 perceive the bicycle as a means of transportation that is less polluting than the other means of transportation.
	9.68	0.00	- Users with income between R$2000.00 and R$4000.00 have the bicycle as the only means of individual transportation.

Table 5
ANOVA for nonusers of shared bicycles.

Variable	F	Sig.	Result
Sex	4.78	0.03	- Women do not use the bicycle because they perceive that the relief of the city does not favor their use.
	6.22	0.01	- Women do not use the bicycle because cycling does not match their lifestyles.
	8.26	0.00	- Women do not use the bike because they perceive the traffic is not safe for cycling.
Income	2.40	0.05	- People with incomes between R$4000.00 and R$7000.00 do not use the bicycle because they do not have a bicycle.
	2.81	0.02	- People with incomes between R$4000.00 and R$7000.00 do not use the bicycle because of the distance of their daily commutes.
	2.82	0.02	- People with incomes between R$4000.00 and R$7000.00 do not use their bicycle because cycling does not match their lifestyles.
	2.75	0.02	- People with incomes between R$4000.00 and R$7000.00 do not use the bicycle because they perceive that the climate of the city does not favor use.
Marital status	3.17	0.04	- Married people do not use the bicycle because cycling does not match their lifestyles.
Number of children	8.58	0.00	- People without children do not know how to ride a bicycle.
	4.75	0.03	- People without children realize that they do not have bike stands to store their bicycles.
Educational background	2.59	0.02	- People with graduate degrees wear clothes that do not favor the use of bicycles.
	4.45	0.00	- People with graduate degrees perceive that the traffic is not safe for cycling.

traffic and using the bicycle as an alternative means of transportation, which also justifies the use by those with higher levels of schooling. Working in Passo Fundo is a significant variable because bike users that work in the city seek to contribute more to the city's traffic and prefer follow sustainability practices. In relation to income, users with incomes between R$2000.00 and R$4000.00 believe that the bicycle is a less polluting means of transportation than the other means of transportation, and the bicycle is their only form of individual transportation.

Considering the group of nonusers, there were statistically significant differences ($p < 0.05$) in the variables of sex, income, marital status, number of children, and educational background (Table 5).

Considering nonusers of the bike-sharing program, we verify that the females do not the bicycles because they perceive that some aspects do not fit to their lifestyles, the bicycles are unsafe to use in traffic, and the city does not favor cycling activities. These results are similar to findings in the literature (Fishman et al., 2014; Mateo-Bibiano, 2015): The use of shared bicycles was not favored due to insufficient cycling infrastructure for a safe ride. The bike lane portion with higher elevations tended to be depleted, and less inclined stretches tended to be crowded. This problem often occurs when individuals use bicycles downhill but use another means of transportation to return, leaving the bikes behind (Midgley, 2011).

Nonusers with an income between R$4000.00 and R $7000.00 do not use the bicycle because of the distances of their daily commutes. Similar results were found in an Australian study, which identified the distance between residence and work as the main barrier to nonuse of shared bicycles (Fishman et al., 2014). Nonusers also believe that using a bicycle does not match their lifestyles and the weather does not favor cycling. This finding collaborates the findings in Mateo-Bibiano (2015): People prefer using buses to bicycles due to unfavorable climatic conditions. Regarding marital status, statistically significant differences ($p < 0.05$) were observed in married nonusers, who did not use the bicycle because they also believed that it did not match their lifestyles.

Individuals who have a larger number of children are less likely to use bicycles because they do not know how to cycle or because the number of bike stations are not satisfactory. Finally, the educational background also influences nonuse because people with a higher level of education believe their clothing does not favor the use of the bicycle and that the traffic is not safe for cycling.

Comparing the different means of transport for users and nonusers, we observe that the car is the means used by 43% of the interviewees when they go to work, followed by "on foot" (22%) and by bus (18%). However, when asked about which means of transportation they would prefer, bicycle is first and the choice for 36% of respondents, followed by "on foot" with 34%, and by car with 27% (Table 6).

Table 6
Users and nonusers of shared bicycles regarding the means of transportation that they use and the means they would prefer.

	Means used (n)	%	Means preferred (n)	%
Bus	93	18	14	2
Car	228	43	141	27
Bicycle	49	9	187	36
On foot	116	22	177	34
Others	40	8	7	1
Total	**526**	**100**	**526**	**100**

This study reveals obstacles considered barriers to the adoption of the bicycle as a means of transportation (De Sousa et al., 2014).

These barriers are precisely relevant in the case of female respondents because the female audience comprises the largest percentage of the group of nonusers. Along these lines, this study demonstrates that the main factors affecting the group of nonusers regarding not using the bicycle as a means of transportation were (i) cycling does not fit the respondent's lifestyle; (ii) the traffic is not safe for cycling; (iii) the city does not favor cycling activities (i.e., mountainous relief); and (iv) the cycling of long distances daily is insurmountable.

Actions can help to reverse this situation by benefiting the users of the bike-sharing program and attracting new users. Through an ICT platform, for example, users could be informed in advance about the best places to remove or leave the bicycles, improving the distribution offered at each bike station (Kaltenbrunner et al., 2010). In addition, studies analyzing cyclic mobility patterns can improve the distribution of bicycles at stations (Kaltenbrunner et al., 2010).

This type of community-based platform can lead to the optimization of bike-sharing systems and emphasize the importance of its planning phase to provide an attractive option for transportation by minimizing the barriers observed in this study. In addition, this type of community-based platform would help to improve user satisfaction with the service, making citizens more likely to use shared bicycles, and realize significant sustainability impacts.

The findings also suggest that a bike-sharing system is well accepted when it has high potential to become part of the city's identity. However, the public bike-sharing programs must be constantly monitored, and its development must be context-specific. From this perspective, policymakers' understanding of the different aspects that motivate bike-sharing system users is essential to avoid inhibiting use.

5. Conclusion

This research aimed to fill the gap in the literature on bicycle sharing systems in emerging countries analyze the motivations for using shared bicycles in the context of an emerging country. To analyze the motivations and identify the factors of adhesion to the system, a survey was completed by users and nonusers in the city of Passo Fundo, in southern Brazil.

The study revealed three main factors that motivate users of bike-sharing programs. The first factor, with the highest level of significance, was "health and environment" and refers to the user's perceived contribution regarding reducing traffic and improving the environment and public health. The second factor was "social influencer," showing that what motivates users of sharing bikes is when they perceive cycling as a sustainable practice (i. e., following practices adopted in developed countries and influencing the emergence of new users). As third factor, the study found the "cyclist lifestyle," in which users are motivated because cycling is part of their lifestyle.

To understand the main reasons for using shared bikes, we used ANOVA, which showed statistically significant differences ($p < 0.05$) for both groups. For the users, there were differences in sex, civil status, educational background, and income. The main reason for bike-sharing adoption was the possibility of contributing to reducing traffic. In the group of nonusers, the statistically significant differences ($p < 0.05$) were observed in the variables of sex, income, marital status, number of children, and educational background. For the nonuser group, the main motivation for not using shared bikes was related to a lifestyle mismatch.

Several indicators aimed to measure the smartness of a city. Beyond the degree of technology adopted, the efforts for smart city development should include citizen's participation and engagement. Regarding pollution levels and the length of a bike lane, further research must be conducted to access citizens' perceptions of a smart city and how they use the public areas available to them.

As objective indicators are not sufficient for a meaningful measurement of city smartness, the researchers recommend future studies on citizen's perception on well-being that consider that the cities are the new actor of sustainability in practice. Some of the questions should include, but are not limited to, the following: What elements are absent and what elements affect the citizens' well-being in the context of smart cities? When adopting subjective indicators, does it continue to make sense to compare one city to another city? How does the smart city concept help improve citizens' well-being? These questions are recommended as future research topics.

In summary, the smart city concept is far from being constrained to the application of ICTs to cities. The sustainable smart city is continuously creating and developing its physical and social environments with a focus on citizen's participation, collective engagement, and well-being.

This finding calls for a better understanding of the planning and management of smart cities in conjunction with citizen's perception and their effects on the city smartness. The research provides contributions to understand the interconnected aspects of bike-sharing systems in the smart cities context. From a smart city perspective, the research concludes that success within the domain of smart mobility can be achieved by observing the three factors revealed by the analysis. According to our results, fulfilling these criteria through public policies would increase the rate of use of bike-sharing programs and create a green behavior trend. Finally, the study provides relevant information for social researchers and urban planners by identifying factors that influence citizen's perceptions of bike mobility and providing elements for political and academic debate.

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