Towards a better understanding of the factors influencing the likelihood of using shared bicycle systems and frequency of use

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Abstract

Planning and transportation professionals are promoting a variety of more sustainable travel alternatives, such as public transit usage, walking and cycling, to provide individuals a variety of affordable transportation options and counter the negative effects associated with widespread car use. In their traditional form, these alternative transport modes do not always provide the flexibility or convenience the car offers; therefore, innovative solutions have recently been developed to allow active and public transport to better compete with the car. The present paper will focus on one of those innovations, namely the shared bicycle system. This new cycling option is adopted by a growing number of cities or regions throughout the world, yet little is known about the users of the systems and their motivations. A survey was conducted in Montréal, Canada in the summer 2010 to determine the factors encouraging individuals to use the system and the elements influencing the frequency of use. The factor that was found to have the greatest impact on the likelihood of using a shared bicycle system is the proximity of home to docking stations. Owning a yearly shared bicycle membership was associated with users riding shared bicycles 15 additional times per year. Respondents have also shown that they value shared bicycle's "trendy" status and the role it can play in bicycle theft prevention. In order to maximize the potential of shared bicycle systems, it is recommended to increase the number of docking stations in residential neighborhoods, and to put the emphasis of advertizing campaigns on the popularity of shared bicycle and its role in theft prevention.

Keywords: bicycle sharing – BIXI – motivators – deterrents – frequency of use

Introduction

Bicycle sharing systems are increasingly seen as a promising initiative to encourage cycling, whose benefits to the user and to the society as a whole are well known. Cycling is a form of physical activity in which health authorities place great hope as it can be easily incorporated into daily routines and yields cardiovascular benefits for both children and adults *(1)*. It is also an environmentally friendly transportation mode *(2)* that provides additional mobility options at an affordable cost.

Bicycle sharing systems are implemented with the intention to yield those benefits associated with cycling while providing additional convenience for the user, in the hope to convince more people to adopt the bicycle for short trips. A bicycle sharing program can be described as a system that enables individuals to use bicycles whenever they need it, without most of the costs and responsibilities associated with owning a bicycle *(2)*. The flexibility of this transport mode makes it especially suitable for short distances and for one-way trips. All these characteristics prompt a growing number of cities to implement bicycle sharing programs. Currently, bicycle sharing systems are present in over 125 cities on four continents, which translates into about 140,000 shared bicycles worldwide *(2)*.

Despite the growing popularity of shared bicycle systems, little is known about users of shared bicycles, their reasons for using this form of transportation, and more generally about the demand for shared bicycle programs. In the following paper, we will seek to shed light on these questions. More precisely, the purpose of the research is two-fold. First, we will try to determine the socioeconomic and spatial factors that influence someone's likelihood of using shared bicycles. Then, we will look more specifically at people who are already using the bicycle sharing system, and analyze characteristics influencing their frequency of use. This research is based on a detailed online survey conducted in Montréal, Canada in summer 2010. The survey included demographic, travel behavior and spatial questions to determine the elements affecting the use of and opportunities for cycle-transit integration, and a distinct section on the use of BIXI, Montréal's shared bicycle system.

Literature

Bicycle sharing is a relatively recent concept; the first large-scale system was implemented in the Netherlands less than fifty years ago, in 1965. Bicycle sharing systems went through four major phases. The first generation, labeled "White bikes", consisted of unlocked bicycles randomly located throughout the city. The bicycles were painted in one bright color. They could be picked up and left anywhere in the city, and their use was free of charge. In most cases, including the Amsterdam, Cambridge (UK) and Milan experiences, the programs were put to an end after a few years due to the high number of bicycles damaged and/or stolen *(2-4)*.

A second generation of bicycle sharing systems, called the "Coin-deposit systems", was introduced in the 1990s to overcome the problems encountered with the first-generation programs. These systems were characterized by the unique, robust design and bright color of the bicycles as well as designated docking stations where bicycles were borrowed and returned (*3*).

The stations were equipped with a locking system to minimize theft risk and required a small deposit to borrow a bicycle that was generally refunded upon return. Although they were an improvement relative to the previous generation, the coin-deposit systems still did not completely solve the theft problem due to the anonymity of the borrowing process. Furthermore there was no time-limit to the bicycle usage which caused people to borrow bicycles for unduly long periods of time *(2)*. Most of these systems were implemented in Northern European countries, such as Denmark and the Netherlands *(4)*.

The third generation "IT-based systems" kept some of the second generation's features such as the distinctive design of the bicycles and the presence of docking stations. In addition, these bicycle sharing programs were incorporating transaction kiosks which allowed for the identification of users (with portable phone and/or credit card number). These systems have succeeded in declining theft rates since users are exposed to penalties if they failed to return the bicycles back to a station *(2)*. Users also had to get memberships to utilize the service. Typically, usage was free for a certain period of time (in most cases from half an hour to one hour) and then users were charged for the extra minutes, thus encouraging shorter trips. The first city to implement such a bicycle sharing system was Lyon, France in 2005, soon followed by many other European cities *(2, 5)*.

The latest and fourth generation of bicycle sharing programs, the "Demand responsive, multimodal systems" consists mostly of management and efficiency improvements to the IT-based systems. The innovations include mobile and/or solar-powered docking stations, the use of smartcards, and bicycle distribution systems *(2-3, 6)*. Distribution systems involve moving shared bicycles from one station to another in order to ensure that bicycles and empty racks are always available for users to borrow or return a bicycle at any station. The shared bicycle system of Montréal can be included in this last category of shared bicycle systems.

The literature on the evolution of bicycle sharing systems is limited, but reliable and relatively easy to access. Unfortunately, the same cannot be said of research studies exploring the characteristics of bicycle sharing users and the motivators or deterrents to the use of shared bicycles. Very little is known about the potential influence of socioeconomic, spatial or behavioral characteristics of bicycle sharing users or about the attributes of the system itself such as the pricing, the extent of the network, the availability of bicycles or the location of docking stations.

Case Study

Cycling and bicycle sharing in Montréal

According to the latest *Origine-Destination* survey (a regional transportation survey that takes place every five years), the modal share of cycling in the region of Montréal is around 1.2% of all trips *(7)*. In the past few years, the city of Montréal expressed a commitment to improve the cycling conditions. The transportation plan of the city, launched in 2008, specified many interventions to reach that goal, such as implementing the BIXI system, doubling the cycling network, and increasing the number of bicycle racks for parking by fivefold. Although the plan has not yet reached completion, the size of the network increased steadily since its

implementation. Unfortunately, bicycle theft is a problem in Montréal. According to the police department of the city, about 2,500 bicycles are reported stolen every year on average, yet this number represents only a small proportion of all bicycle thefts *(8)*.

BIXI – Montréal's bicycle sharing system

The bicycle sharing system of Montreal, BIXI (for a contraction of bicycle and taxi), was launched in the spring of 2009. It was one of the first "Demand responsive, multimodal systems" to be implemented. The BIXI system is in operation from April 15 to November. At the time BIXI was launched, there were about 300 stations available, but the instant success of the system prompted the BIXI organization to implement the expansion phase ahead of schedule. There are currently about 405 stations distributed throughout the central neighborhoods of Montréal, and a total of 5,050 bicycles are in circulation *(9)*. The BIXIs were designed specifically for shared use in an urban context: they are robust, yet esthetically pleasant and convenient for users with their adjustable seats, front racks and integrated chain protector, which prevents chain grease from getting on the riders' clothing *(10)*. There are three BIXI membership types: the 24-hour pass, the monthly membership, and the yearly membership. The system is meant to accommodate short trips, with the first half-hour of use free and then a charge for additional time. Discounts are also available for individuals who combine their BIXI membership with an annual transit pass or a membership for Communauto (the carsharing service in Montréal). Since the implementation of the bicycle sharing system, over 3,000,000 trips have been made by BIXI, as of fall 2010 *(11)*.

Data

An online survey on cycling and transit integration was conducted in the region of Montréal, Canada during summer 2010. The questionnaire consisted of six different sections: general travel habits, transit questions, cycling-transit questions, priorities for improving cycling and transit integration, and general demographics and comments. It also included a separate section on BIXI usage, since it is one of the viable options for integrating cycling and public transit. The survey was performed using an uncontrolled online distribution method, which means anyone could go on the web page and fill out the questionnaire. It was available online for approximately one month. Many different media, such as mailing lists, email newsletters, social networking media, radio and newspaper interviews, and flyers distributed at major transit stations were used to publicize the survey, in order to ensure a large cross-section of the general population would be reached. The use of such a variety of means allows for broader exposure, thus minimizing the bias that can be associated with online surveys *(12)*.

A total of 1,787 responses were gathered for the survey; after removing the incomplete observations, we obtained a final sample of 1,432 respondents. The ages of the respondents range from 18 to 87, however the majority falls between the ages of 25 and 35. Men are slightly more numerous than women in the sample,accounting for 58% of the respondents. Young people with no child are overrepresented among our respondents compared to the Montreal population,

the majority of them living in small households of 1 or 2 people. More detailed descriptive statistics of our respondents are presented in Table 1.

Individuals who participated in the survey live on average 6km away from downtown Montréal, and they have a good access to transit with an average of 12 bus stops within a 400m distance from their residence. This might explain why the majority of respondents are bus users (they took the bus at least once in the past year). Respondents also enjoy good access to the shared bicycle system, with almost 60% of those who participated in the survey living within close proximity to a BIXI station. Around 87% of people in the sample have a valid driver's license and 52% own at least one car per household.

Table 1 – Selected descriptive statistics of the respondents

	Average	Max	Min
Age	35.7	87	18
Home-downtown distance	6.0	-	-
Number of bus stops within 400m from home	12.1	155	0
Number of bicycles stolen per respondent	0.7	9	0
	Average (%)		
Gender(female)	41.8		
Recreational cyclists only	6.6		
Year round cyclists	16.7		
Bus user	76.8		
Yearly BIXI membership	16.7		
People living within 500m from a BIXI station	59.4		
Respondents who had a bicycle stolen	39.0		

One section of the survey was specifically about the cycling habits of our respondents. Almost all of them (94%) own a bicycle. Close to 40% of the respondents indicated they had already had one bicycle stolen, and 10% had two or more bicycles stolen. As for the cycling habits of our respondents, almost 17% of the participants to the survey use their bicycle for transportation year-round, while another 6% is cycling only for recreational purposes. In terms of bicycle sharing trends, 37% of our respondents indicated they had already used BIXI. Considering this group of BIXI users, membership types were split almost evenly between pay-per-use and yearly enrolments, while only 1% of BIXI users had acquired a monthly pass. Respondents were also asked about their motivations for using BIXI. These motivations and their answers to more specific questions concerning how they integrated BIXI in their transportation habits are presented in Figure 1.

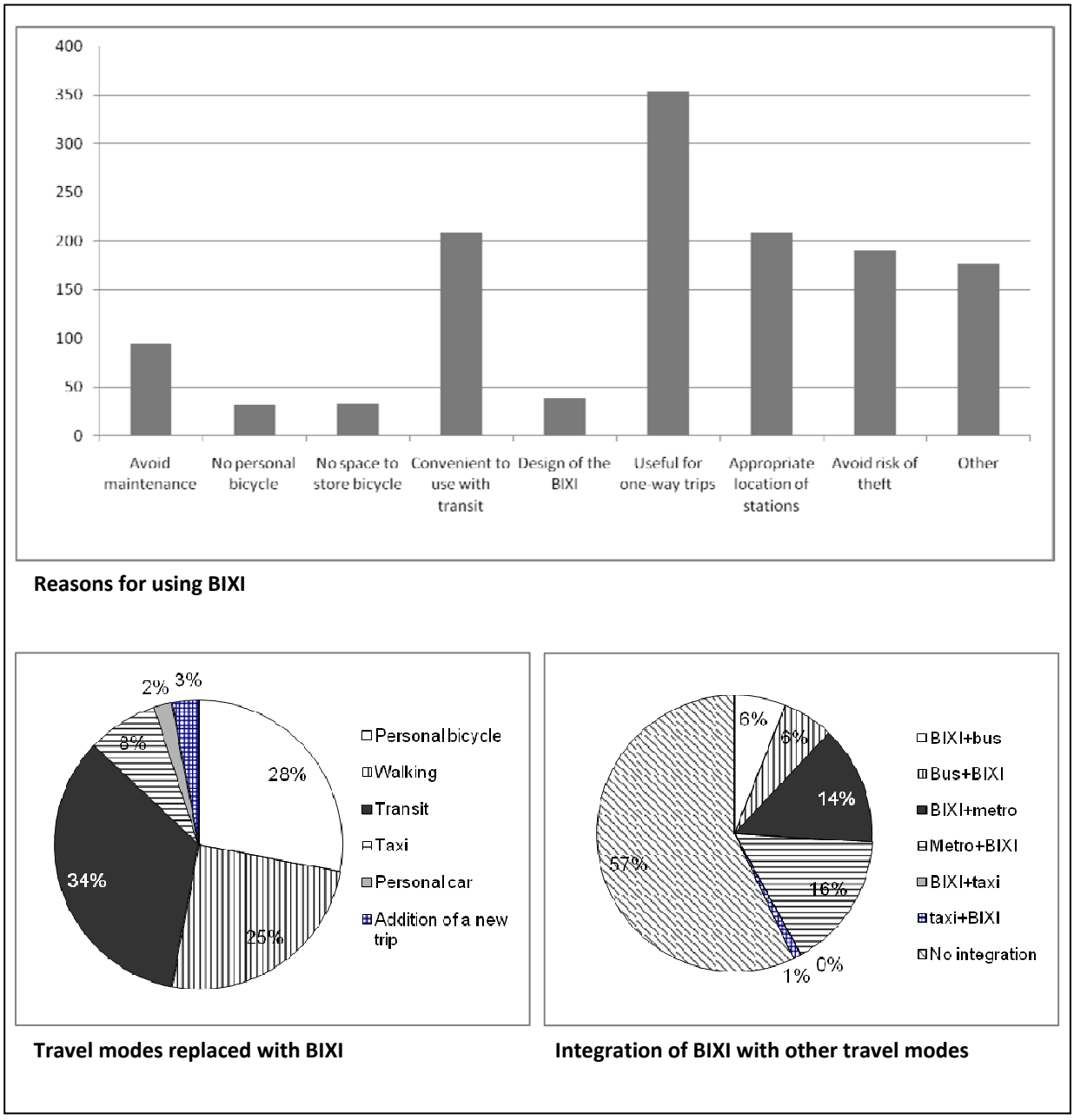

Figure 1: BIXI usage among our respondents

Figure 1 shows that our respondents use BIXIs for a variety of reasons, mostly related to convenience or to avoid maintenance and risk of theft. Most people in our sample are using BIXI for trips previously made by transit or with their own bicycle. Only 10% of the respondents indicated that they used a BIXI instead of taking their car or a taxi; the environmental benefits of BIXI are therefore probably not the main advantage of the system. Despite its potential for multimodal trips, acknowledged by the respondents themselves, less than half of the users combine BIXI with another mode for a trip. When they do so, most of our respondents use BIXI in combination with the metro.

Methodology

Two different types of regressions were used to answer our research questions. First, a binary logistic model is developed to determine factors encouraging the use of BIXI. A binary logistic model is a type of logistic regression in which the dependant variable is binary. In this case, the dependant variable is the previous use of a BIXI (yes/no). Then, a linear regression was applied on our subsample of BIXI users to identify factors that have an impact on the frequency of use of shared bicycles. The dependant variable in this second model is the number of BIXI uses for the 2010 season. A variety of variables were tested in the first model, based on results of previous studies examining the motivators to cycling in general or to using shared bicycle systems specifically. According to those studies, the typical user of shared bicycle system is a young man earning a medium-class income *(13)*. We hypothesized that our analysis would confirm that trend, and we therefore included age, gender, and income as variables in our model.

We also expected that travel habits would have an impact on the likelihood of using BIXI; we hypothesized that people cycling only for recreation would be less likely to be part a bicycle sharing system. We supposed that owning a bicycle and being a committed, year-round cyclist would decrease the probability of using BIXI. Shared bicycle systems offer potential for combined cycling-transit trips or for replacing short bus trips; therefore, we expected that bus users and people who already combined cycling and transit for a trip would be more likely to use shared bicycles. In contrast, we hypothesized that owning a driver's license would decrease the odds of being a BIXI adept.

A recent study on BIXI identified the proximity to docking stations as an important motivator to the use of the system *(6)*. We supposed that our analysis would generate similar results, especially since that paper focused specifically on shared bicycles in Montréal. We also expected that living close to downtown would increase one's likelihood of using BIXI, since this type of residential location is generally associated with shorter, more "bikeable" travel distances. Finally, we decided to explore a hypothesis not yet tested in the literature and specifically related to Montréal's cycling context. As previously mentioned, bicycle theft is a problem in Montréal, and fear of theft can deter people from using their bicycle for transportation. In this respect, shared bicycles represent a good alternative as users do not own the bicycles and therefore they do not need to worry about it being stolen while the bicycle is parked. Consequently, we expect that those who have had their bicycle stolen, and thus are more conscious of theft risk, will be more likely to use shared bicycles.

Many of the same variables were included in the second model, yet other distinct factors could also influence the frequency of use. First, we incorporated in the model the type of shared bicycle membership; we expected that owning a yearly membership, with unlimited access to BIXI system for the first half-hour would encourage people to use the system more often. We added variables representing reasons for using shared bicycles, in order to determine if some of the advantages of BIXI have an impact on users' behavior. Avoiding maintenance, avoiding risk of theft, and liking the design of BIXI (which can be considered as the "trendiness" factor of the BIXI) were among the most popular reasons mentioned by our respondents and therefore were included in the model. Finally, the number of bus stops within a 400m buffer from residential location was added as a variable representing the level of transit access of respondents. We expected that having a good access to transit would diminish the need for shared bicycles. All

variables included in both models were tested for correlation. Other variables such as household size, car ownership and a variety of interaction variables were tested in the two regressions but proved to be insignificant and were therefore removed from the final models. The two models presented below are those that were able to explain the highest proportion of variance among the data with meaningful and significant variables.

Analysis

The result of the binary logistic regression measuring the probability of using a BIXI during the 2010 season is reported in Table 2. There are three main types of variables that have shown to play a significant role in the likelihood of using shared bicycle systems: socioeconomic characteristics, transportation habits, and spatial characteristics. The variable that has the strongest impact is the presence of a BIXI station less than 500m from home, which makes an individual more than 300% more likely to use a shared bicycle, thus confirming the results of previous studies stressing the importance of proximity to docking stations *(9)* at the home location. The proximity of a BIXI station to respondent's most regular destination is also increasing one's probability of using a BIXI, but is not as critical as the proximity to home. Being a recreational only cyclist and being a female would decrease chances of an individual to use a BIXI, while combining cycling and transit for trips and owning a driver's license would have the opposite effect. Although it might seem counterintuitive that being a driver makes someone more likely to use shared bicycles, this result is consistent with findings from a Chinese study *(13)*. Age and distance from home to downtown would have a marginal but significant negative impact. The distance from home to downtown squared was also tested in this model to account for the possibility of a non-linear relationship between distance and probability of use, but the variable was not significant and was consequently removed from the final model.

Table 2 – Factors influencing the likelihood of using shared bicycle systems

Variable	Odds ratio
Age	0.965***
Gender (female)	0.585***
Owning a bicycle	0.5778**
Cycling for recreational purposes only	0.437**
Number of bicycle thefts	1.104*
Owning a driver's license	1.588**
Annual household income from 0 to 40,000$	0.539***
Being a bus user	1.486**
Distance from home to downtown	0.956**
Being a year-round cyclist	0.539***
Presence of a BIXI station less than 500m from home	3.245***
Presence of a BIXI station less than 500m from destination	1.559**
Already combined cycling and transit	1.772***
Constant	0.769
-2 Log likelihood	1509.905
Nagelkerke R square	.241

*Significant at the 90% confidence level
**Significant at the 95% confidence level
***Significant at the 99% confidence level

Interestingly, people who earn less than $40,000 per year are 32% less likely to be adepts of bicycle sharing than people falling in other income brackets, thus corroborating findings from previous studies that users are mostly middle-income (in Quebec, the median annual household income was slightly over $64,000 in 2009)*(13,14)*. People cycling throughout the year and those

owning a bicycle are less inclined to use shared bicycles, which might mean that "cycling enthusiasts" are not the typical BIXI users, who may be more casual cyclists. Finally, each time an individual gets his bicycle stolen increases the likelihood of being a BIXI user by 10%.

Table 3 reports the findings from the linear regression measuring the number of times a person has used the bicycle sharing system in the 2010 season.

Table 3 – Variables influencing frequency of use of shared bicycle systems per cycling season (spring to fall)

Variable	Coefficient
Constant	9.766**
Age	-0.004
Gender (female)	-1.335
Owning a bicycle	-5.680**
Owning a yearly BIXI membership	15.911***
Using BIXI to avoid risk of theft	5.310***
Using BIXI to avoid maintenance	10.992***
Using BIXI for its attractive design	10.352***
Number of bus stops 400m from home	-0.093*
Distance from home to downtown	-1.142*
Distance from home to downtown squared	0.063**
Number of bicycle thefts	0.455
N	535
Adjusted R square	0.502

*Significant at the 90% confidence level
**Significant at the 95% confidence level
***Significant at the 99% confidence level

First, we can notice that some of the variables found in both models such as age, gender and number of bicycles stolen are not significant in predicting the frequency of shared bicycle use although they influence the probability of someone using shared bicycles. Owning a yearly BIXI membership has the greatest impact on the number of uses of a shared bicycle, increasing by 15 the number of times a person would ride a BIXI per season. People who want to avoid maintenance of a bicycle and those who appreciate the design of the BIXI are likely to use it 10 more times per season. Also, owning a bicycle decreases the number of uses of a shared bicycle by 5.6 times per season. As for spatial characteristics, living close to downtown slightly decreases the number of uses, yet past a certain threshold, distance to downtown has the opposite effect. The presence of a BIXI station within a 500m buffer at both ends of the trip was also

tested in the linear regression, but proved to be insignificant and was consequently removed from the final model. Finally, the number of bus stops within 400m from home has a small but significant negative impact on frequency of use, which might indicate that BIXI is competing with transit

Discussion

The most obvious finding of our first model is that having a BIXI station close to home has the most influence on increasing the likelihood of a rider to use shared bicycles. Proximity of the stations to regular destinations also augments the odds of being a BIXI user, yet the effect of this variable is not nearly as strong. This might also be partly due to the fact that only the most regular destination was included in the analysis. Therefore, to increase the modal share of BIXIs, more stations need to be installed in residential neighborhoods in priority.

As of now, docking stations are only available in some central neighborhoods with good access to the transit network, and most of the users do not combine their BIXI ride with another mode for a single trip (probably because of their good access to transit and proximity to downtown). It would be interesting to observe patterns of use if BIXI stations were installed in more peripheral neighborhoods or in areas with a more limited transit access. Many of the factors which increased the probability of using shared bicycles are related to transportation habits; those combining cycling and transit, bus users, and people owning a driver's license are more likely to be BIXI users. We originally expected the possession of a driver's license to have the opposite effect, yet our result is not counterintuitive as it seems. Most adults in Montréal have a driver's license; therefore, chances are great that an adult shared bicycle user also is a driver, whether or not they own a car or drive on a regular basis.

Inversely, being a very committed, year-round cyclist and owning a bicycle would decrease one's chances of using BIXI. People using their own bicycle have similar travel options and enjoy the same health benefits shared bicycle users do and are therefore not the group targeted in priority by promotion campaigns for shared bicycle programs. Yet it would still be worth investigating whether bicycle owners choose not to use BIXI for convenience reasons or because of the cost of the membership, which could be prohibitive for someone who already has access to a personal bicycle free of charge (except maintenance).

One very interesting finding from this study is that people who have already had their bicycle stolen are more likely to use shared bicycles. Respondents who expressed a concern about bicycle theft as a reason for using BIXI are also riding shared bicycles more often. This indicates that BIXI is perceived and, indeed, acts as an effective solution for those who want to cycle yet are afraid of bicycle theft. The potential of shared bicycle systems as a powerful tool to counteract the negative influence of bicycle theft on the modal share of cycling is obvious. This study goes one step further as we can now confirm that this advantage is valued by individuals, as it encourages those who experienced theft to start using the system and also increases the frequency of use of individuals concerned with bicycle theft.

More generally, we can conclude from the results of our analysis that factors prompting people to become shared bicycle users are not necessarily the same as those increasing the frequency of

use of this transport mode. Spatial factors and transportation habits play an important role in encouraging individuals to use shared bicycles, yet specific the respondent's motivations for using BIXIS have the greatest impact on the frequency of use.

Aside from fear of theft, another motivation that increases the frequency of using BIXI is the design of the BIXI, which makes individuals use it on average 10 more times per year. This is a clear indication of what we call the "trendiness factor" of the BIXI. The design of the BIXI and its promotion as an urban, environmentally-friendly mode contribute to make it "trendy" to be a shared bicycle user, and consequently to the popularity of the BIXI.

One limitation of our study is related to the distribution method of the survey, and the risk of bias associated with voluntary-based surveys. We addressed this shortcoming by using multiple dissemination tools to reach a broad cross-section of the population. The main limitation associated with our study is that we could only use socioeconomic, transportation habits and spatial variables to generate the model; therefore the influence of the values of respondents could not be evaluated in our analysis. . Finally it is important to note that tourists using the system during their visit were not included in the survey. Reaching out to this special population of Bixi users requires a different study and a different approach to capture their usage of the system.

Conclusion and policy recommendations

A growing number of municipal and regional governments recognize and wish to enjoy the benefits associated with shared bicycles. In order to make the shared bicycle programs successful and to maximize their potential, it is essential to get a good understanding of factors prompting or deterring individuals from using the system. The current study allowed us to have a better understanding of the factors influencing the use of shared bicycle systems and those impacting the frequency of use. The results of this research point out to some key elements to consider in the formulation of policies for promoting the use of shared bicycles.

We suggest that interventions focus on four major aspects that impact the likelihood of being a shared bicycle user and the frequency of use:

1) **The location of shared bicycle stations**: This study has shown that the location of docking stations plays a crucial role in encouraging individuals to use shared bicycles. A greater number of docking stations close to origins of potential users in residential neighborhoods is highly likely to generate an increase in the number of system users. The study has also shown that proximity of docking stations to destinations augments the odds of being a BIXI user, yet its impact is more limited than proximity to origins.
2) **The transportation habits of current and potential users:** Transit users, people combining cycling and transit for their trips, and those who have a driver's license are more likely to use shared bicycle systems. Special multimodal offers, including access to shared bicycle systems, carsharing systems, or integrated multimodal fare cards, would encourage individuals to adopt shared bicycles by making the integration into their current travel habits as seamless as possible.

3) **The fear of bicycle theft:** Our study confirms that individuals recognize shared bicycles as an interesting active travel option in minimizing bicycle theft. Promotion of the shared bicycle systems should insist on this advantage in order to attract new users and increase frequency of use among those who have already had bicycles stolen in the past or those concerned with the risk of theft.

4) **The status and perceptions associated with shared bicycles:** Individuals who like the design of shared bicycles tend to use the system more often. Advertizing campaigns sending the message that it is "trendy" to use shared bicycles are likely to encourage users to increase their frequency of usage of the system.

This research, based on a survey of people living in the region of Montréal, Québec, provided findings that are consistent with results of previous studies conducted elsewhere in the world. Although each region has its own particularities, we believe the main findings from this study could be useful for any city aiming to maximize the potential of its shared bicycle system.

In the specific case of Montréal, the implementation of the BIXI system had impacts that have gone beyond the augmentation in shared bicycle usage. Many experts have observed an increase in the overall number of cyclists, and a positive shift in the social status associated with utilitarian cycling in general. In this specific case, the implementation of a shared bicycle system in the city not only improved the range of sustainable travel options, but it also truly contributed to the cycling culture in Montréal, which requires some further investigation in the near future.

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