

Sustainability obstacles of free bike-sharing model

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Abstract. Cycling is one of the options for sustainable urban mobility. Although this transport mode is not so widely used in Slovak cities, the bike-sharing project in Žilina with 80 thousand inhabitants has been remarkably successful. The system comprises of 120 shared bikes and 20 bike stations located mainly in the city core and wider centre to cover important transport destinations. During the first-year usage, a great interest of citizens has been recorded also thanks to the one-hour-free-of-charge service. That leads to an average rental number of 35 thousand bicycles per month (with a maximum of 47 thousand) and a high usage rate of the system (on average, 9.5 rides per bike per day). A more detailed analysis, including the Covid-19 pandemic's impact on reducing bicycle rental, is presented in the article. In addition to the positive experience with the bike-sharing system, the disadvantages of the one-hour-free service model are discussed. In addition to the reduced service availability for citizens with real transport needs or higher users' disrespect to the system, the technical operation costs are about 40 % higher due to an excessive wear system, poorer technical condition, and shorter lifespan of bicycles, or increase in a certain form of vandalism due to the bicycle joyriding. Ultimately, the overall loss is much higher because of no income, which threatens the sustainability of this system.

1. Introduction

There are several options to ensure sustainable urban mobility and to reduce the environmental impact and energy consumption related to the mobility of citizens. One of them is the creation of infrastructure and conditions for cycling, for instance, a bicycle sharing system. Bike-sharing service provides an opportunity for residents as well as visitors to use other alternative modes of urban transport in the city. This mode ensures relatively fast, flexible, and especially emission-free transport. Furthermore, this also motivates people to move, which improves health as can be seen from the conclusions of twelve major bike-sharing systems in Europe [1]. In addition, bike-sharing can be motivational for the use of a bicycle as a commonly available mode of transport in the city on a private basis. Also, preferring a bicycle over a car improves public space and the quality of the urban environment, and reduces demands on the parking spaces. A well-designed and operated bike-sharing system can bring also economic benefits. Individual benefits and public good benefits in an economic context are demonstrated for example on the Dublin bike-share scheme [2]. However, for a successful and long-term sustainable bike-sharing system in the city, it is important to have a well-established service pricing policy.

The article describes the bike-sharing system in the Slovak city of Žilina with 80 thousand inhabitants and its enormous usage of this system. One of the main reasons for its widespread use is

the fact that the service is free-of-charge for up to one hour. The effects of this free service model on the sustainability of the bike-sharing system are discussed in this article.

2. Brief description of the bike-sharing system in Žilina

The bike-sharing system in Žilina (BikeKIA) has started at the end of March 2019. It is a part of the international bike-sharing system Nextbike operated by ARRIVA Slovakia. This system comprises of 120 shared bikes and 20 bike-sharing stations located mainly in the city centre and wider central parts of the city to cover the important strategic points, such as centres of residential areas, university area, university dormitories, or health and shopping centres (see figure 1). The maximum distance between stations is 4.5 km, most are within 500 meters. Except for two stations (No. 18 and 20), they are all on a flat plane terrain.

The bike-sharing station network is connected via the Internet. Each bicycle is equipped with a SMART Lock, GPS locator, and GSM communication. Renting a bicycle is based on a registration system with payment card verification. This registration is possible via the web or an application, and then the user opens the bicycle from the stand using a smartphone. Visitors and residents of Žilina can rent a bike free of charge for one hour, without a registration fee or deposit. It is possible thanks to the support of the non-profit Kia Motors Slovakia Foundation and the City of Žilina. Based on the memorandum, they will finance the operation of the service for 5 years without any revenue from the system.

A pricing scheme for the BikeKIA system is quite simple. It contains only basic tariff (for the first 60 minutes for free), service fee, and technical fees as shown in table 1.

Table 1. The pricing scheme for the BikeKIA system.

Basic tariff	the first 60 min FOR FREE	The bike must be returned to an official bike station within 1 hour of biking FOR FREE. Then it is possible to rent another bike straight away – for 1 hour FOR FREE again.
Service fee	20 EUR	The fee for every additional hour if the bike is not returned within 1 hour. 24 hours max.
	100 EUR	
Technical fee	75 EUR	The bike was stolen because of negligence.
	75 EUR	The damage was done to the bike / rental station / bike stand.
	25 EUR	The bike was not returned to an official station and returned or locked incorrectly.
	10 EUR	The use of the bike does not comply with the General Terms and Conditions.

3. Utilization of the BikeKIA system

The analysis of bike-sharing utilization in this contribution is conducted based on the raw data from the BikeKIA system supplied by the operator (start time, end time, duration, rental place, return place, and bike number). The period analyzed in this paper is the first-year operation between April to November 2019.

The location and utilization of bike-sharing stations are shown in figure 1. The size of the circle represents the number of bike rentals from a given station. The most frequently used stations are in the city centre and wider city centre (No. 1, 4, 5, 6 and 8), next to the university dormitories (No. 2 and 7), inside the largest residential area (No. 3), next to the shopping centres (No. 9, 11 and 13), and Žilina reservoir (No. 10) with several opportunities for sports and relaxation. The least frequently used stations are on the hill at the university area and the forest park (No. 18 and 20) and also in the city center near frequently used stations (No. 17 and 19).

The difference between the number of bicycle rentals and returns on frequented bike-sharing stations is between 1-7% (see figure 1, right), which indicates a sufficient redistribution of shared bikes and variety of bike-share rides during a day.

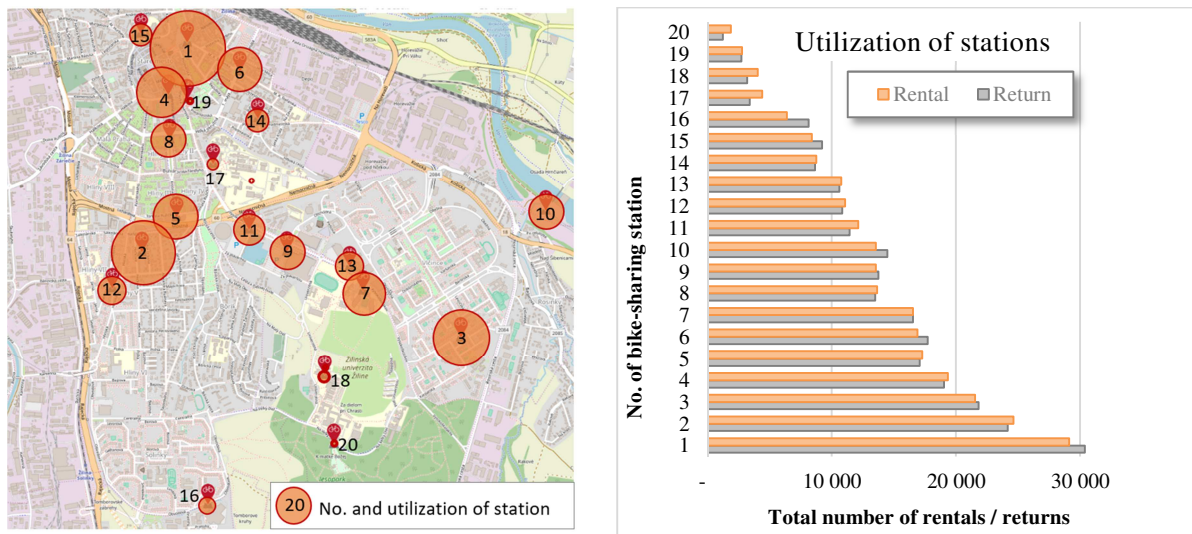


Figure 1. Utilization of rental stations.

The usage of the BikeKIA system is shown in the chart in figure 2. The total number of bicycle rentals (bike-share rides) was about 280 thousand over the period with an average of about 35 thousand per month. The highest number of bicycle rentals was achieved in the first month of full operation, the lowest in November due to the weather. A lower number of rentals were also recorded during the summer holidays and in September when there are fewer university students in the city.

To demonstrate the BikeKIA system utilization, the usage rate of the system (an average bike-share rides per day per bicycle) was determined. It ranges from 6 to 13 rides per day per bike depending on the month with an average value of almost 9.5 (see figure 2). On some days in the first period of the service operation, the usage rate reached the value of 20 rides per day per bicycle.

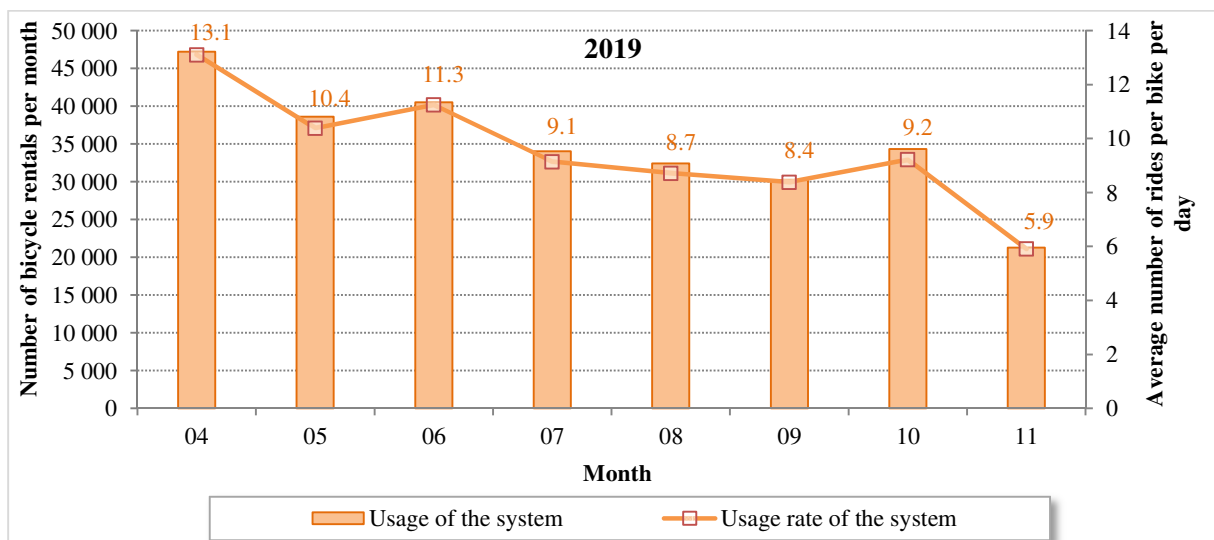


Figure 2. Utilization of the BikeKIA system.

Covid-19 pandemic's impact on reducing the usage of the system is presented in figure 3. The first two months, March and April, are omitted because the system was not in operation at that time due to coronavirus and state of emergency with strong restrictions in Slovakia. In May 2020, when several companies had a home-office mode, and the university, all schools, and many shops were closed, there

was a decrease in the total number of bike-share rentals in comparison with 2019 of about 60 %. In June 2020, when the university and most of the schools were closed, there was a decrease of about 40%. In July 2020, during the summer holidays and the standard mode without more significant restrictions due to coronavirus, there was a decrease of only about 14%.

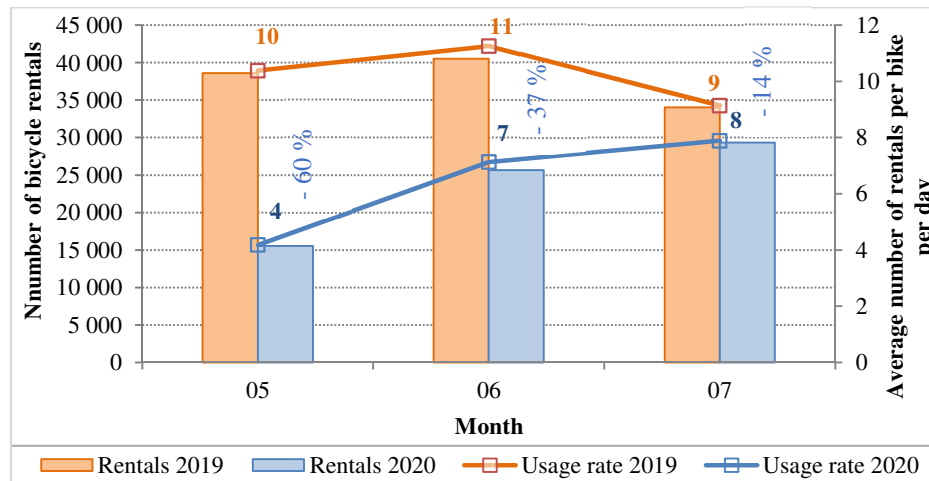


Figure 3. Covid-19 pandemic's impact on the usage of the BikeKIA system.

Presented data indicate a huge usage of shared bicycles in the city of Žilina. This can be confirmed in comparison with systems in some selected Slovak and Czech cities (see table 2). It is possible to see up to 3-4 times higher usage rate of the BikeKIA system compared to other systems.

A high utilization rate of the BikeKIA system is also evident in comparison with the average number of rides per day per bike of bike-sharing systems in large cities such as Barcelona (6.5), Washington DC (3.8), Miami Beach (3.2) or Melbourne (0.7) [3].

Table 2. Comparison of usage rates of bike-sharing systems (2019) ^a

City	Number of inhabitants in thousand	Number of stations	Number of bicycles	Average number of rentals per day	Usage rate of the system
Žilina	81.1	20	120	1 142	9.5
Bratislava	424.4	74	400	1 020	2.6
Kladno	69.0	50	100	180	1.8
Ostrava	289.6	210	600	1 893	3.2
Prostějov	43.7	37	100	212	2.1
Havířov	72.1	20	80	265	3.3

^a Source: processed based on data in [5, 6, 7]

The main factors influencing a high utilization of the BikeKIA system include:

- free-of-charge bicycle rental for up to one hour, even several times a day,
- easy registration without any registration fee or deposit,
- inhabitants with a relatively low average age (36 years), quite a lot of young people - students and university students,
- flat plane terrain (just only two stations are on the hill),
- optimal allocation of bike-sharing stations mainly in the city core and wider center with covering strategic points,
- sufficient variety of bike-share rides ensuring natural redistribution of the shared bicycles during a day,
- existing cycle routes, which are relatively safe,

- short distances between stations,
- reliable and simple system,
- good quality of operational service,
- good marketing.

4. Rental duration analysis

Since the BikeKIA system is free for 60 minutes, the bicycle rental duration was also analyzed. The results in figure 4 show that most rentals take less than 20 minutes (73.1 % to 86.5 % by month, with an average of 78.0 %). The proportion of rentals exceeding an hour is only 0.4 %, which is related to the fact of free-of-charge rental for one hour. The proportion of rentals exceeding 20 minutes (20-60 minutes) is more than 20 %. The average rental duration is around 16 minutes.

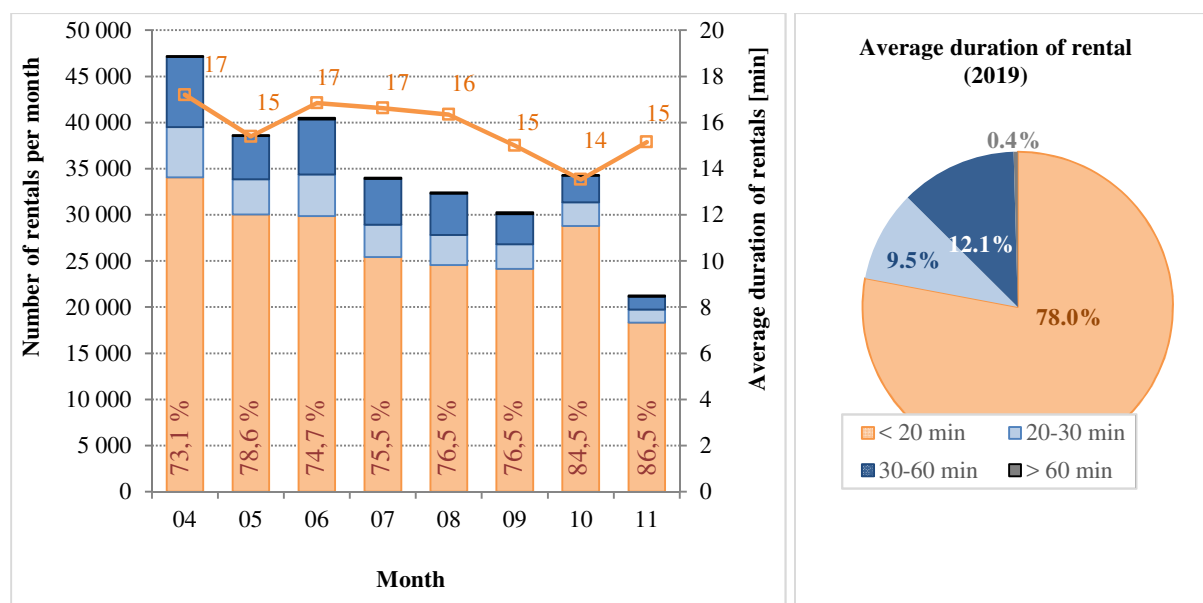


Figure 4. The average duration of bicycle rentals.

A more detailed analysis of raw data has been revealed, that too long free-of-charge rental time supports an unnecessary prolongation of rentals and usage of shared bikes for non-transport purposes instead of effective interstation rides. These too long rentals mainly include “too long rides” (extended or interrupted rides because they are free) and “rental rides” (rental station and return station is the same). Experience has shown that these “rental rides” often include the usage of shared bikes mainly by young users for fun (usage for joyrides).

The proportion of “rental rides” from all bike rentals during the observed period of 2019 is represented by an average value of 11.6 % (7.1 % - 15.3 % depending on the month). Most “rental rides” were recorded at the Žilina reservoir station (No. 10; about 42 %), and at the most frequently used stations (No. 1, 2, and 3; about 15 %).

To determine the proportion of unnecessary long rides, the rental-return matrix of rental duration limits was determined. For the setting of these limits, average travel times (depending on distance and average speed 10 km/h) and the Modes of a set of data (rental durations) for all trips between stations were calculated. As an example, processed data for the two most frequently used trips are shown in figure 5. Rental duration limits have always been set higher than the mode of rental duration and average travel time (by about 30 % higher than the average travel time depending on distance and longitudinal slope). Rental durations exceeding the set limits were considered as “too long rides”.

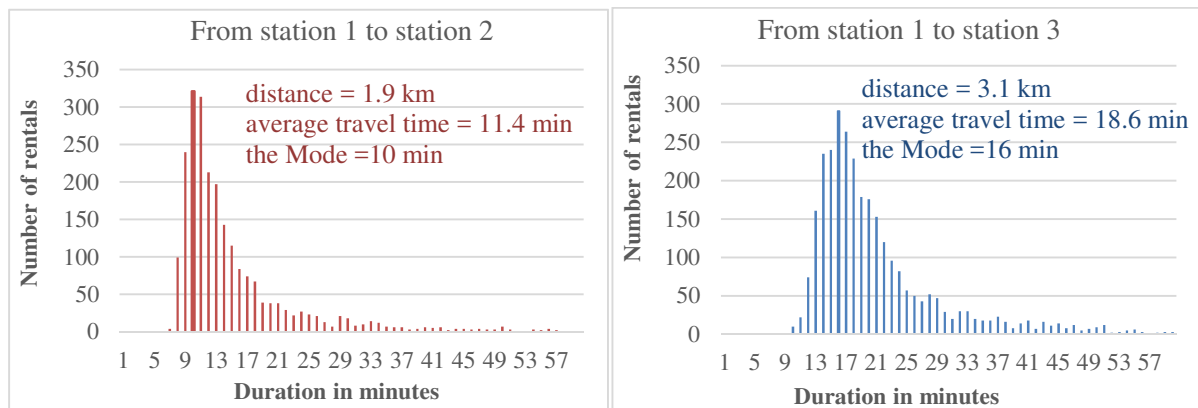


Figure 5. Processed data of rental durations for two most frequently used trips.

Results for the observed period of 2019 show that only 65 % of all rentals were carried out for travel purposes from the origin (rental station) to the destination (return station) without unnecessary delays (effective interstation rides). The remaining percentage means using the shared bike for purposes other than just effectively moving from point A to point B (too long rides and rental rides). Further analysis revealed that these rentals are much longer than rentals for effective interstation rides. More than half of these rentals exceed 20 minutes (see table 3).

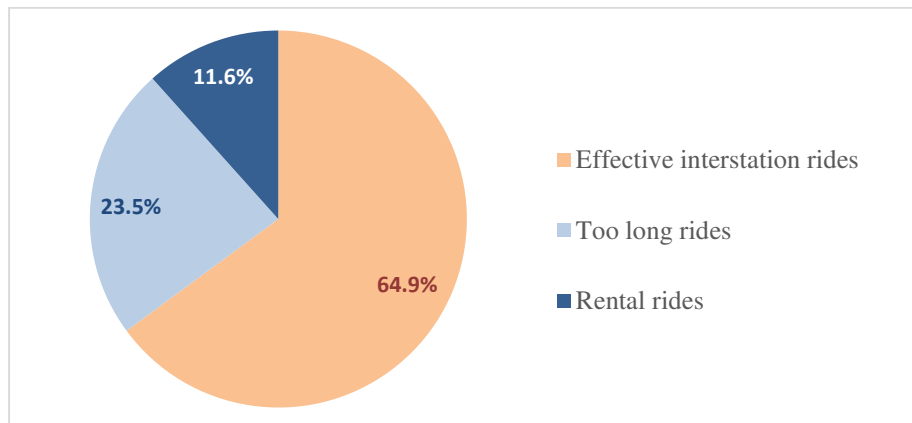


Figure 6. The proportion of bicycle rentals by type of rides.

Table 3. Comparison of rental durations by type of bike-share ride.

Rental duration	The proportion of the rentals in %		
	Effective interstation rides	Too long rides	Rental rides
< 20 min	96.6	42.4	47.7
20-30 min	3.2	24.6	14.0
30-60 min	0.2	32.1	37.0
> 60 min	0.0	0.9	1.2
Total	100.0	100.0	100.0

5. Effects of the free-of-charge service of the BikeKIA system

Excessive usage of the BikeKIA system thanks to the free-of-charge service model up to an hour significantly affects the sustainability of this system, especially in two areas:

- quality of the service for users,

- financial sustainability of the system.

They are threatened mainly by:

- excessive wear of the system,
- worse technical condition and shorter lifespan of bicycles,
- increased requirements for redistribution,
- increased number of unnecessarily long rentals,
- increased certain form of vandalism and careless handling of bicycles due to their usage mainly by young users for fun (usage for joyrides),
- higher users' disrespect to the system.

In terms of the service quality, these aspects have the effect of reducing the functionality and reliability of the system, user safety as well as the availability of this service for users with real transport needs. Availability of the service is given by the availability of bicycles, which is reduced due to more frequent repairs and charging bicycles, or using bicycles for joyrides mainly by young users, unnecessary rides, or too long rides.

In terms of the financial sustainability of the system, the above-mentioned aspects result in higher requirements for repairing, maintenance, and cleaning of bicycles which is associated with an increased need and amount of work and materials (spare parts). For such an excessive used system, material costs have proved to be almost double and the need for additional working time for technicians almost 30 % higher compared to the standard used system. These increase the technical operating costs of the system by up to 40 %.

6. Conclusions

The article presents a successful bike-sharing project in Žilina with data demonstrating the enormous usage of this system. One of the most important reasons for such a large usage of the system is the free-of-charge service - for up an hour, several times a day, and without registration fees or deposit. This aspect, together with a well-designed and operating system thus offers a new opportunity for free and ecological mobility of residents and visitors to the city. On the other hand, this threatens its long-term sustainability, especially in two areas: quality of the service for users and the financial sustainability of the system. In terms of the service quality, there are effects of reducing the functionality and reliability of the system, user safety as well as the availability of this service for users with real transport needs. In terms of the financial sustainability of the system, there are impacts on higher technical operating costs of the system, which can be up to 40 %. Ultimately, the overall loss is much higher because of no income.

The data analysis in the BikeKIA system shows that too long rental time for free unacceptably supports an unnecessary prolongation of rentals and the use of shared bikes mainly by young users for joyrides instead of an effective interstation rides This results not only in reducing the availability of bicycles but also increased financial demands due to a certain form of vandalism and careless handling of bicycles.

To ensure the use of a bike-sharing system for effective transport, while enabling free rental service, it is necessary to change the rental conditions to eliminate as much as possible undesirable rentals. One of the options is a significant reduction in rental time for free and the collection of a registration fee or deposit. The rental time for free should be considered based on detailed data and financial analysis. Another contribution to reducing vandalism and negligent treatment of bicycles can be an increase in the fine, improving the intelligent monitoring of bicycles and rental stations, and the support for other users in this monitoring.

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