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FIFTH GENERATION OF BIKE-SHARING SYSTEMS – EXAMPLES OF POLAND AND CHINA

Summary. The article is focused on sustainable transport development solutions in cities, such as bike-sharing systems. We discuss the main principles of bike-sharing, its generations, types, and benefits to system users and entire urban transport systems. The aim of the article is to present a comparison of bike-sharing systems found in Polish and Chinese cities. The authors also consider new market practices, which can be implemented when introducing or improving current bike-sharing systems.

Keywords: bike-sharing systems; sharing economy; urban transport systems; sustainable transport development

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1. INTRODUCTION

Congestion in city centres, excessive ecological standards and insufficient parking spaces are just a few of the many problems that modern cities have to cope with. Therefore, in the era of increasing sustainable urban and transport development, cities are looking for solutions that could help to improve existing urban transport systems. Such activities are aimed at changing these cities' orientation towards cars (automobile-oriented cities) in an attempt to adapt their environment to the needs of society, especially pedestrians and cyclists. However, in order for this to be fully realized, one should look for solutions that will ensure a balance between ecological, economic and social aspects [1-9].

One of the solutions is to focus on the capabilities that can implement a concept of sharing economy. According to its assumptions, sharing economy activities mean: sharing or renting goods or services via an online platform or a mobile app [10]. In the case of transport, there are many ways to operationalize a sharing economy, mainly in relation to passenger cars, bicycles and scooters, or car-sharing, bike-sharing and scooter-sharing, respectively [11].

The purpose of this work is to present a comparison of bike-sharing systems operating in selected Polish and Chinese cities. The authors identified basic issues related to bike-sharing systems and their advantages for individual users and urban transport systems. In addition, based on the resulting analysis, the differences in operating systems and practices, which may be helpful in modernizing current or implementing new bike-sharing initiatives on the markets, will be discussed.

2. BIKE-SHARING SYSTEMS

Bike-sharing is a system involving the self-service rental of bicycles, mostly located in city centres [12,13]. The system allows users to rent a bike for a selected period of time (even for a few minutes) via a mobile application. Its essence is based on the possibilities offered by classic rental systems without needing to contact an office. Rentals can be made 24 hours a day and payments are taken from the user's bank account or credit card.

Bike-sharing is not a new concept in the world. Its beginnings date back to 1965, when Amsterdam introduced the first bike-sharing system in the world called the White Bicycle Plan [14]. In turn, along with the development of technology and the desire to change attitudes towards urban mobility, new bike sharing systems have appeared on the market and experienced several generations. Currently, several kinds of bike-sharing systems exist. According to the literature, there have been five generations of bike-sharing systems [15-18]:

- First generation - "Witte Fietsen" system in Amsterdam in 1965 was the first type of bike-sharing system, which operated for free; most of bikes were stolen.
- Second generation - "Bycyklen" in Copenhagen in 1991, the first temporary self-service rental with the possibility of returning bikes in exchange for a coin deposit,
- Third generation - Started at Portsmouth University, UK, in 1996, followed by "LE Vélo STAR" in Rennes in 1998, "Bicing" in Barcelona in 2007, "Cycle Hire" in London in 2010 and "Citibike" in New York in 2014. These systems involved the usage of magnetic cards, telecommunication systems, electronically locking racks and mobile phone access,
- Fourth generation - Systems with smart bikes, accessed by mobile app, connected with an integrated traffic management system (intelligent transportation technology) and real-time information provision.
- Fifth generation - Systems with dockless bikes and big data management possibilities.

Depending on the operator, bike-sharing systems can be private initiatives or partnerships with the public transport sector, car park operators or bike-share operations [19].

The trend in this area indicates that new bicycle rentals are appearing on a global scale. Statistics show that, at the beginning of 2017, bike-sharing operated in over 1,000 cities around the world [20], with the world's largest bike-sharing rental system located in the city of Hangzhou, China [21]. One of the bicycle stations in Hangzhou is shown in Fig. 1.

Fig. 1. Example of bike-sharing loan station, Hangzhou, China
Source: authors' own collaboration

Bike-sharing systems offer many advantages to individual users and the entire urban transport system, including [22-25]:

- Providing an opportunity to limit the number of vehicles in the city in the form of an alternative means of transport
- Complementing the offer of the urban transport system
- Offering a solution to the "last mile" when travelling to places where transportation is limited or prohibited
- Making a positive impact on quality of life in the city by providing better mobility
- Supporting park-and-ride systems
- Making a positive impact on the environment by reducing the generation of fumes, pollution, noise or vibrations
- Making a positive impact on users' health by providing more traffic as a substitute for car travel
- Increasing the attractiveness of an area both for investors and for tourists
- Offering economic advantages, as they do not require the costs associated with the purchase, service and maintenance of bikes
- Eliminating risks related to the fear of the bike theft, as they do not require the purchase, for example, of additional security against the unauthorized use of a bicycle or insurance
- Improving transport accessibility by increasing the use of stores in areas where it was difficult to park a car previously

3. CASE STUDY: DOCKLESS BIKE-SHARING SYSTEMS IN POLAND AND CHINA

Several types of bike-sharing systems and their huge popularity have led to the emergence of an increasing number of such systems that can be classified as 'fifth generation'. These systems allow for bikes to be left in a public place anywhere in a city where this kind of system exists. This type of transport solution is called dockless bike-sharing. Examples of bikes left in the Chinese cities of Hangzhou and Shanghai without the use of docking stations are shown in Figs. 2 and 3.

Figs. 2-3. Examples of dockless bike-sharing stations in Hangzhou and Shanghai, China
Source: authors' own collaboration

The Chinese companies Ofo and Mobike are pioneers in the implementation of dockless bike-sharing systems. Ofo started its operations in Beijing in 2015, while Mobike was launched in Shanghai in 2016 [26]. In Poland, this type of city bike is currently operational in Cracow (Wavelo, since 2016) and Warsaw (Acro-bike, since 2017). Many Polish cities are currently at the stage of choosing a bike-sharing system to be implemented in the future. Several years of experience gained by Chinese cities and the initial phase of operation in two aforementioned Polish cities may inform the authorities' decision.

The general concept of operating a dockless bike-sharing system is similar for all companies offering this type of city bike initiative. Fig. 4 shows the scheme for the operation of a dockless bike-sharing system. The first two steps should be only be carried out during the initial use of the system. Compared with traditional bike-sharing systems with docks, there is no step associated with finding a destination dock.

Fig. 4. Scheme of the dockless bike-sharing system operation.
Source: authors' own collaboration

All systems have a dedicated app that allows the user to send money to a virtual wallet and find an available bike, which can be unlocked by this application. Some applications also have built-in additional functions, such as memorizing the route travelled, navigating or reporting bike damage.

Tab. 1.

Different approaches to unlocking bikes in dockless bike-sharing systems in China and Poland

Different approaches to unlocking bikes			
China		Poland	
Ofo	Mobike	Wavelo	Acro-bike
Scan QR code with rented bike's plate number	Scan QR code	Input ID and PIN into the user console	Connection via Bluetooth

Source: author's own collaboration

Dockless bike-sharing systems have differences in their details, which are relevant to the user. Tab. 1 presents various approaches to unlocking dockless bikes. Renting a bike from Mobike requires the user to only scan the QR code (located on the lock of the bike) via a smartphone with the installed app. The Ofo solution also requires a QR code scan and the additional entry of the four-digit code found on the frame of bike. The bike system introduced in Cracow allows the user to rent a bike after logging into the on-board computer located at the back of the bike by entering unique user numbers (account and PIN). The Warsaw bikes are unlocked from the app by establishing communication with the bike by means of Bluetooth transmission.

An important aspect of the operational bike-sharing systems is the method of payment. Most often, companies use their own virtual wallets. In China, however, dockless bike-sharing system apps enable the use of the popular virtual wallet available on WeChat. The described solution is preferable for users as there is no need to create an additional wallet.

The introduction of a fifth-generation bike-sharing system in China has not only changed the urban landscape, but has also affected the design of urban infrastructure. Directly collected data from GPS devices placed on bikes allow for the travelled route to be identified. This solution enables the implementation of the Internet of Things concept [20] in the system. Planners responsible for the implementation of transport in the city have access to data that facilitate the improvement of city traffic [27-30].

In order to analyse various aspects of the introduction of fifth-generation systems, a literature-based query was carried out. The main advantages and disadvantages of dockless bike-sharing systems are presented in Tab. 2.

The main advantage of dockless bike-sharing systems is the possibility to park a bike anywhere in the city without having to search for a dock with available parking space. This feature offers users immense flexibility in the choice of destinations routes, as there are no restrictions related to the location of docks. With a large number of bikes in such systems, their availability is improved, which increases the comfort of using city bikes [31].

The said, dockless bike-sharing systems are more vulnerable to thieves than traditional systems. Due to the possibility of being able to leave the bikes anywhere, they are often in a poor technical condition. This is caused by the difficulty of maintaining and repairing bikes in many locations. Users of dockless bike-sharing systems often park bikes in unauthorized

places, making it difficult for other users of road infrastructure to move, e.g., by parking a bike in the middle of a pavement. Another problem is leaving bikes in "little-known" places, for example, a location that is rarely frequented by others, where the probability that someone else will use bikes parked there is small.

Tab. 2.
Main advantages and disadvantages of dockless bike-sharing systems

Advantages	**Disadvantages**
Availability of bikes	Theft of bikes
No dependence of the user's destination route from where the nearest docking station is located	Poor technical condition
No problem with overcrowded docking stations	Parking bikes in the wrong places

Source: authors' own collaboration

Dockless bike-sharing systems offer many advantages to users. Unfortunately, it also has disadvantages that may have a negative impact on other road users. The introduction of new infrastructural solutions may help to eliminate such disadvantages, such as special zones based on geolocation, where users have permission to park bikes. In addition, city centres should create designated zones for parking bikes on the pavements, which are marked with horizontal signs.

4. SUMMARY

Dockless bike-sharing systems offer great potential in terms of supporting sustainable transport development cities. The analysis of data on such systems highlights how they can facilitate better management and planning of traffic in the city.

Dockless bike-sharing systems are very attractive to users because they offer cycling options without the need to find a destination dock. Unfortunately, for the entire transport system, these systems pose some risks related to parking bikes in unauthorized places. As this can affect the safety of all road users, it is important to establish bike-parking restrictions.

In pursuit of the efficient management of bike-sharing systems, using artificial intelligence, including image analysis methods [32-35], could undoubtedly help. Such possibilities should be considered when planning future investment.

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