FACTORS IMPACT ON THE SUCCESS AND FAILURE OF BIKE-SHARING SYSTEMS - EXPERIENCES FOR HO CHI MINH CITY

CÁC YẾU TỐ ẢNH HƯỞNG ĐẾN SỰ THÀNH CÔNG VÀ THẤT BẠI TỚI HỆ THỐNG CHIA SẺ XE ĐẠP CÔNG CỘNG - KINH NGHIỆM CHO THÀNH PHỐ HỒ CHÍ MINH

[1]Doan Hong Duc, [2]Nguyen Van Thuong
[1, 2] Faculty of Transportation Engineering
Ho Chi Minh City University of Transport

***Abstract**: The increase of motorized vehicles has many adverse effects on the public such as traffic congestions, traffic accidents, emission, and human health. Therefore, public transport and non-motorized vehicles play an important role in the transport system in which including bike-sharing services. However, few studies give a comprehensive understanding of implementing a bike-sharing system (BSS) in the context of HCMC. This study aims to determine factors impact on the success and failure of a BSS in the world and then define the specified factors based on HCMC's traffic conditions. As a result, the authors propose general guidelines for BSSs implementation in the context of HCMC.*

***Keywords:** Bike-sharing system, performance, planning, public transport.*

***Classification number:** 1.3*

***Tóm tắt:** Nhu cầu sử dụng phương tiện giao thông cơ giới cá nhân ở Việt Nam ngày một tăng, điều đó đã và đang gây ra nhiều tác động tiêu cực đến xã hội như tắc nghẽn, tai nạn giao thông, ô nhiễm môi trường và sức khỏe con người. Do đó, giao thông công cộng và giao thông phi cơ giới ngày càng được chú ý hơn, trong đó có mô hình chia sẻ xe đạp. Tuy nhiên, hiện nay ở Thành phố Hồ Chí Minh (TP.HCM) có ít các nghiên cứu mang tính hệ thống trong việc triển khai các mô hình chia sẻ xe đạp. Mục đích của nghiên cứu này là đưa ra một cái nhìn toàn diện về các yếu tố tác động đến sự thành công và thất bại của các hệ thống chia sẻ xe đạp trên thế giới. Từ những bài học kinh nghiệm đó, tác giả chỉ ra các yếu tố ảnh hưởng đến các mô hình chia sẻ xe đạp trong điều kiện của TP.HCM. Kết quả là đề xuất hướng dẫn chung cho việc triển khai các hệ thống chia sẻ xe trên địa bàn Thành phố.*

***Từ khóa:** Hệ thống chia sẻ xe đạp, hiệu suất, quy hoạch, giao thông công cộng.*

***Chỉ số phân loại:** 1.3*

1. Introduction

Bike-sharing services have been receiving increasing attention from the public, travelers, policymakers as well as transport planners. The service has many benefits, especially, in public transport systems, last-mile problem-solving. The success of a bike-sharing system (BSS) depends on various factors, such as urban sprawl, social-economic, private car ownership rate, and traffic conditions.

In HCMC, urban sprawl has affected the transportation infrastructure of the cities and road network coverage rate, especially, the public transport system. When people start to choose to live outside the city and commute to work, this may cause an increase in vehicle ownership rate. Economic growth and social-economic development influence the travel demand that plays an important role in the feasibility of BSSs. Besides, mixed traffic and jammed traffic have negative effects on public transport and bike-sharing usage. Moreover, public awareness and government support in bike-sharing services also take an important place in the success of BSSs. There are some pilot projects of bike-sharing in Ho Chi Minh City that implemented on the campus of the Quang Trung Software City (2017) and the urban area of Vietnam National University-HCMC (2018). However, until now, only a few studies have defined a suitable assessment framework for the implementation of BSSs in cities like HCMC. Therefore, it is significant to know important factors impact on the success of BSSs and to determine a general guideline that able to implement BSSs in HCMC.

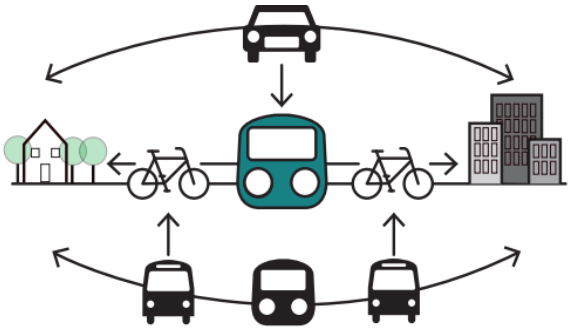

Figure 1. *Bike provides a door-to-door transport connection.*

Source: *www.bitibi.eu.*

The objective of this study is to propose overall guidelines for implementing a BSS in cities in Vietnam. As the first step, a systematic review is performed covering the impact factors used to assess BSSs. Based on that, in the next step, the various factors are categorized and estimate the significance levels. Then, general guidelines for implementing a BSS are proposed that considered with the particular implementation gaps in Vietnam. Finally, the drawbacks and recommendations of the study are presented.

The paper consists of four main sections. Section 2 gives an introduction of BSSs and presents the significant findings of the literature review. Based on the findings, section 3 provides a detailed discussion and propose a general guideline for BSS in cities in Vietnam. Conclusion and recommendations for future studies are mentioned in section 4.

2. Related work

2.1. Bike share overview

The bike-sharing scheme is defined in "Optimising Bike Sharing in European Cities-A Handbook-2011" as "a self-service, short-term, one-way-capable bike rental offer in public spaces, for several target groups, with network characteristics.". Gauthier et al., (2013) indicated that there are five main components impact on the success of a BSS, including (i) station density, (ii) bikes per resident, (iii) coverage area, (iv) quality bikes and (v) easy-to-use stations. The following table shows significant indicators of those components.

Table 1. *The main components of a BSS.*

Components	Descriptions
Station density	10-16 stations / 1 km^2 300-meter buffer - convenient walking distance
Bikes per resident	10-30 bikes / 1,000 residents
Coverage area	Minimum 10 km^2
Quality bikes	Durable, attractive and practical
Easy-to-use stations	Simple process, easy-to-use interface

Source: *ITDP, 2014.*

A quality BSS needs to provide the ability for the user to access and overcome the constraints of time and distance. The average distance between stations should be about 300 meters that improve the convenience of walking. The number of bicycles in residential areas must satisfy the demand of both commuters and residents. The ITDP has recommended the coverage rate of a BSS should be at least 10 square kilometers that ensure the usage of BSSs. The design of the bicycle also affects the convenience and the attraction of the service. The operation process of BSSs must be simple and easy to use.

2.2. Factors affect the success of BSSs

This section presents the influenced factors that impact on the success or failure of a BSS. The following table shows the summarized list of factors in the literature.

Table 2. *Factors used in assessing BSS in literature.*

Authors	Factors
Abolhassania et al., 2019	Safety; Accessibility; Cost; Convenience; Employment status; Gender
Chardon et al., 2017	BSS attributes; Density and compactness; Geographic Weather; Transport infrastructure
Shen et al., 2018	Supply; Cycling facilities; Density; Diversity; Design; Access to public transportation; Weather conditions; Temporal and other factors; Spatial factors

Source: *Own illustration.*

It can be seen that there are different ways of the determining success or failure of a BSS. That depends on the feasibility of assessment

methodologies and available data. Chardon et al., (2017) used a trip per day per bike (TDB) as a key performance indicator to determine the level of success of BSS. The TDB evaluation is calculated for 75 BSS case studies in Europe, the United States, Canada, Brazil, Australia, and Israel. Chardon et al., (2017) defined the necessary factors that need to be taken into account when the performing calculation of TDB. The different factors are showed in the following table.

Table 3. *Detail of influenced factors used to assess a BSS.*

Factors	Detailed Attributes
BSS attributes	- operator types - daily operating hours - membership costs - number of docks at stations - monthly maximum sum of bikes - number of stations
Density and compactness	- the density of stations (km^2) - area within 300m of stations (km^2)
Geographic	- demographic, cultural and legal effects
Weather	- climates, temperate, humidity
Transport infrastructure	- safety conditions, integration of BSS with other modes of public transport

Source: *Chardon et al., 2017 [1].*

It is important to list the detailed attributes of BSS attributes in performance evaluation. Chardon et al., (2017) gathered the detailed components of BSS attributes relating to operation management, the number of available stations and fleet size. Those attributes affect the bicycle travel demands of BSS. It can be seen that the travel demand will directly impact on TDB indicator.

In the case of density and compactness factor, Chardon et al., (2017) mentioned the convenience when using BSS of residents. The factor impacts the willingness to use the service of users. It also reflects the coverage level of bike-sharing services. The served areas of BSS are also identified within the 300m buffer distance from stations.

For the geographic and weather factors, it is clear that these factors impact on using BSS of users. The adverse conditions of climate or temperature will reduce the BSS performance. The low population density areas are also observed with low performance of BSS.

Regarding the transport infrastructure factor, Chardon et al., (2017) presented that cycling infrastructure influenced the use of BSS because of safety aspects. Travelers will consider safety when choosing services, especially for vulnerable user groups.

The values of calculated TDB of 75 case studies indicated that there is a wide range of TDB, with the highest and lowest values are 8.4 and 0.22 trips/day/bike, respectively. Chardon et al., (2017) concluded that the larger systems will have higher performance typically. However, it is significant to note that the TDB needs to carefully consider the network effect, see the following figure.

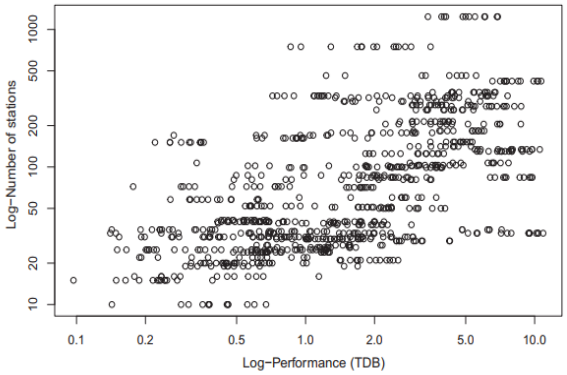

Figure 2. *Network effects and monthly trips per day per bike (TDB) performance values of 75 cases.*

Source: *Chardon et al., 2017 [1].*

It can be seen that BSS has higher available stations that have higher trips per day per bike. And, of course, the fleet size will also impact on TDB values.

2.3. Implementation of BSSs

- ***Travel demand***

An effective BSS is a system that meets the travel demand and satisfaction of users. Frade & Ribeiro, (2014) noted that there are different methods used to predict bike-sharing travel demand. Frade & Ribeiro, (2014) used the examined the number of trips at the generator/attractor points and the choice of shortest distance of user during travel period time to estimate the travel demand of BSS. The authors estimated travel demand for bike-sharing based on trip's purposes, travel time (distances) and slopes. In the end, Frade &

Ribeiro, (2014) referrer to the travel demand matrix and come with probability of using bike-sharing systems. It can be seen that to meet the demand for bike-sharing, it is significant to examine the transportation demand, land use, relationship between land use and travel demand and other related characteristics of traffic infrastructure.

- ***Interaction with other transport modes***

A new BSS is always examined in the context of sustainable transport development. The assessment of BSS combines the interaction of BSS with other vehicle types (Campbell, Cherry, Ryerson, & Yang, 2016). Campbell et al., (2016) mentioned that there are three main relationships of a BSS with other transport modes, including feeder, replacement, or no relation. The BSS can be considered as a feeder system to other public transport systems as buses or mass rapid transit systems. Campbell et al., (2016) also noted that in some cases e-bike share can replace bus systems. For example, when a BSS is attractive as a ‘‘first-and-last-mile solution”, users can use BSS instead of using busses. In the areas of private automobile restriction, e-bike share becomes a replacement transport mode (Campbell et al., 2016).

- ***System implementation***

Campbell et al., (2016) mentioned that cities in China implemented policies that reduce private vehicles and encourage public transport via the cost of bike and pedestrian facilities. While planning and designing bike-sharing services, the local government also implement regulations to control motorized traffic at the same time. In previous work was different policies support bike-share services, such as the expansion of bike-share need to consider in reducing carbon dioxide emissions or considerations for successful BSS (Campbell et al., 2016).

It is significant to note that the implementation process of BSS might include four main stages, including (i) travel demand evaluation, (ii) system design, (iii) system operation management, (iv) satisfaction assessment user. Therefore, the accurate evaluation of each stage will significantly impact the success of BSS.

3. Discussion

This chapter presents the explanation of significant results in the study, including: (i) criteria for implementing a BSS; (ii) qualitative analysis the implementation of BSSs in the context of traffic in HCMC; (iii) the proposed guidelines for BSSs implementation in HCMC. This section tries to interpret the significant findings related to the impact factors based on qualitative analysis.

3.1. Criteria for BSSs implementation

This section clarifies the significant factors for implementing a bike-sharing system based on the findings in the previous section. It can be seen that six factors will affect BSSs implementation, including (i)-road and traffic conditions, (ii)-transportation master plan, (iii)-land use data, (iv)-meteorological and topographical conditions and (v)-questionnaire data.

For each factor, the related attributes are listed in Table 4. Besides, several factors might impact BSSs implementation feasibility, such as the available budget, impact of public transport modes on bike-sharing services, technology and applicable knowledge barriers, public acceptance on bike-sharing. That will also influence the decision of implementing BSSs.

Table 4. *Common factors influence BSS implementation.*

Factors	Description (Parameters – Units)
Road and traffic conditions	a. Geometric design: - road type; width, m; length, km b. Traffic characteristics: - traffic volume, veh/h; flow rate, veh/h; density, veh/km; traffic intensity, veh/day; c. Cycling facilities*: - cycling infrastructure density (km/km^2) - bicycle paths (km) - bicycle supporting facilities - streets in steep slopes (%), etc. d. Public transport facilities:

Factors	Description (Parameters – Units)
	- accessible public transport network - bus stop density (per km^2) - other public transport mode station density (per km^2)
Transportation Master Plan	a. Public transport development - public transport integration - technology designs b. Cycling planning and regulations* - planning for cycling - cycle helmet laws c. Automobile restriction regulations
Land use data	a. Buffer radius, m, km b. Land-use types*, %: - commercial, residential, industrial, etc. b. Population density*, people/km^2
Meteorological and topographical conditions	a. Meteorological conditions: - average total hours of sunshine per year; wind speed, m/s; temperature, ^{o}C, ^{o}F; atmospheric stability; b. Topographical features: - slopes, %
Questionnaire data	a. Travel behavior and mode choice* - trip purposes - vehicle ownership rate - trip rates by purpose and mode choice - mobility pattern - mobility characteristics b. Bike-sharing travel demand - travel demand - user's expectations

Source: *Adapted from Büttner, J., 2011 [6].*
Please note that (*) is a highly important factor.

3.2. BSSs in the context of traffic in HCMC

3.2.1. Road development in HCMC

This section presents the historical change of road networks in HCMC. The road network was structured and organized in the early 1900s. Urban planning was implemented by French that provided quality access for private vehicles and non-motorized vehicles (see Fig. 3).

The urbanization and economic development of HCMC affected the urban expansion and road network. The map of HCMC in 1966 indicated that the urban sprawl of HCMC had a significant impact on travel and accessibility of people (see Fig. 4).

During these periods, the most popular vehicle was the bicycle, and most trips were short distances. Beginning of the 21st century, HCMC's population and economy grew significantly, and that increased travel demand. There is a significant change in the modal share. The use of motorized vehicles increases rapidly. Unfortunately, road network planning is not meet the development and that causes significant traffic issues. The mass rapid transport systems are still under construction or planned. The following maps show the road network by 2020 in HCMC and HCMC's metro system.

Figure 3. *HCMC map in the 1920s.*
Source: *www.saigoneer.com [7].*

Figure 4. *HCMC map in 1966.*
Source: *www.saigoneer.com [7].*

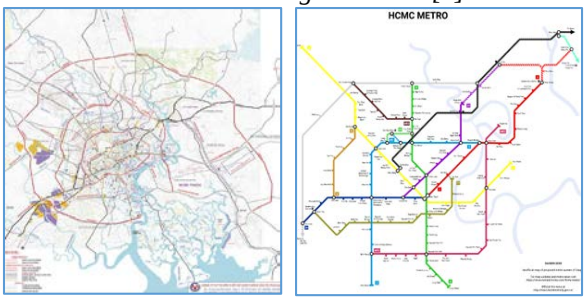

Figure 5. *HCMC's road network by 2020 and HCMC's metro system.*

Source: *www.saigoneer.com*

Travel demand studies conducted by JICA Study Team in 2002 and 2013 indicated that the high growth rate of private vehicles, as shown in the table below.

Table 5. *Daily trip rates* (%).*

Transport mode	2002 (Houtrans) (%)	2013 (Metros) (%)	2013 vs 2002 (%)
Bicycle	9.4	2.8	-6.8
Motorcycle	81.8	83.0	3.3
Car	1.9	5.3	12.6
Bus	4.2	6.3	6.7
Other	2.7	2.6	2.8
Total	**100.0**	**100.0**	**3.1**

Source: *JICA study team*

**: Internal-internal trips are not taken into account*

It can be seen that people tend to use private transport modes including motorcycles and cars for daily trips. Do et al. (2019) presented that although there is a slow increase in using bus services, it remains significant constraints in public transport development. It is lack of public space areas, so people prefer to use private modes than others. As a result, the negative impacts of using cars and motorcycles like congestions, traffic accidents, and air pollution occur more frequently. Local government and policymakers started to pay more attention to the use of non-motorized modes such as bicycles. Nevertheless, the current road infrastructure does not support for cycling. There was no plan for bicycle development in previous transportation planning, so it would be difficult for implementing bike-sharing services. It requires road spaces, public space areas, development policies, etc.

3.2.2 Bike share pilot programs

The Prime Minister required HCMC and other large cities in Vietnam to implement the pilot program of public bike-sharing in 2014. Two systems have been implemented on the campus of the Quang Trung Software City (2017) and the urban area of Vietnam National University-HCMC (2018) (see the following table).

Table 6. *Pilot public bike-sharing programs in HCMC.*

Location	Number of stations	Number of bicycles	Users
Quang Trung Software City (Internal areas)	2 (currently not use)	N/A	Visiting customers, employees
Vietnam National University-HCMC (Urban areas of the university)	5	2018: *80 bikes* After the trial period: *20 bikes*	Students and employees

Source: *Own illustration*

The systems have failed to meet the demand. The number of bicycles has decreased and the system has not been improved after trial time. However, it can be seen that local governments can determine the suitable regulations for bike-sharing based on failure causes.

3.2.3. Constraints in implementing bike-sharing in HCMC

It can be seen that there are several constraints in the implementation of BSS in HCMC. The list of restrictions is shown in the table below.

The failure of the pilot BSSs in HCMC also indicated that there are several constraints in implementing BSSs in HCMC. There is no particular regulation for bike-sharing services in Vietnam. That causes difficulties in planning, designing, implementing and operating BSSs.

The budgets for BSSs in HCMC is also a constraint that is not only impact on planning, design and operating stages but also affects the maintenance stage. The adverse weather in HCMC can cause bicycle damage that requires repair and maintenance costs. In some cases, the bicycle is damaged because of lacking awareness about the regulations of users. The metro systems are now under construction, so the future connections between BSSs and other public transport types

such as bus, waterbus and metro systems need a suitable assessment.

The existing road network in inner-city areas are not accessible for cyclists. Therefore, the location of a BSS requires a significant selection and to take into account multiple stockholders and public interest. It is necessary to ensure convenience and safety while traveling by bicycle for cyclists. Safety is a significant factor for attracting people to use a bike-sharing service.

Table 7. *List of constraints in implementation of BSSs in HCMC.*

Factors	Constraint and challenges
Traffic characteristics	Increase of private vehicles
Transportation infrastructure	Low-quality cycling infrastructure Illegally occupied pavement Low density and quality of public transportation stations
Residents	Travel habits can be difficult to change Lack of understanding of bike-sharing Concerns about traffic safety
Government support – Budgets	Lack of specialized departments for public transport. Limitations of available budgets and land funds
Security	Crime on public transport such as theft, robbery, etc. Lack of awareness of property protection
Weather and environment	Hot weather and air pollution

Source: *Adapted from Büttner, J., 2011 [6]*

3.3. General guidelines for BSS in HCMC

It is significant to propose general guidelines for bike-sharing implementation that includes particular factors and related requirements in the context of HCMC (see Fig. 6).

- **Improving road infrastructure and facilities that support walking and cycling:** Road safety indicator is one of the most important factors that impact on use decision in using BSS. The improvement of infrastructure and facilities for bicycles must be consistent with other transport modes. This should focus on cycling paths, stations, and bicycle supporting facilities. As a result, that will enhance safety for cyclists and the reliability of BSSs.

- **Developing suitable transport plans and particular regulations for bike-sharing services:** Bike-sharing must be considered and assessed in transportation planning of cities. It is significant to develop specific regulations and additional traffic laws related to the bike-sharing service. The regulation is a prerequisite for implementing a BSS.

- **Planning and implement mixed land use patterns that support BSSs usage:** The public transport systems in HCMC have significant improvements. Bus stops have been improved with new shelters, larger areas and easy access for passengers. Waterbus operates around Saigon waterways and can connect to bus services. And, the metro systems are under construction that will provide many connecting stations for bike-sharing services. Those are vital conditions for implementing BSSs. Also, HCMC's government is now providing walking streets including Nguyen Hue street, Bui Vien street. These public space areas are the supportive cycling facilities.

- **Enhance awareness of bike-sharing to change travel behavior of people:** Changing people's travel habits is difficult in the context of HCMC's traffic conditions. Therefore, local government can enhance environmental awareness of the cycling of students and residents in advance. After that, pilot programs should be conducted in public space areas to attract residents and travelers. Based on these activities, people might recognize the benefits of using bike-sharing services.

To summarize, it can be observed that to ensure the success of a BSS and the acceptance of the public in using bike-sharing services that requires a list of prerequisite conditions related to infrastructure, regulation, land use, and travel behavior.

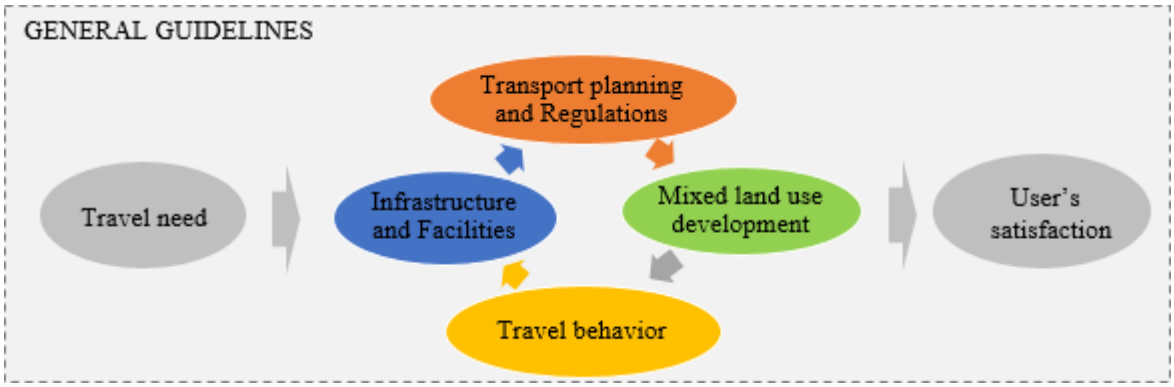

Figure 6. *General guidelines for BSS in HCMC.*

Source: *Adapted from Büttner, J., 2011 [6].*

4. Conclusion and Outlook

The study showed the list of key factors affects BSSs implementation including: (i) - road and traffic conditions, (ii) - transportation master plan, (iii) - land use data, (iv) - meteorological and topographical conditions and (v) - questionnaire data. For each factor, the study described detailed attributes and noted with the significant levels. The local government and other stakeholders might consider implementing based on the priority levels of factors, available budgets, technology, public awareness, etc. Based on the failure causes of pilot BSSs in HCMC, the study also proposed general guidelines for implementing BSSs that are closed to HCMC's context.

It is significant to note that the implementation of BSS can be reality whether the construction of public transport systems including MRT and BRT systems are completed. Furthermore, the local government will play a notable role in the implementation of transit infrastructure, BSSs, and other support facilities❑

References

[1] de Chardon, C. M., Caruso, G., & Thomas, I. (2017). *Bicycle sharing system 'success' determinants*. Transportation research part A: policy and practice, 100, 202-214.

[2] Campbell, A. A., Cherry, C. R., Ryerson, M. S., & Yang, X. (2016). *Factors influencing the choice of shared bicycles and shared electric bikes in Beijing*. Transportation research part C: emerging technologies, 67, 399-414.

[3] Shen, Y., Zhang, X., & Zhao, J. (2018). *Understanding the usage of dockless bike-sharing in Singapore*. International Journal of Sustainable Transportation, 12(9), 686-700.

[4] Frade, I., & Ribeiro, A. (2014). *Bicycle sharing systems demand*. Procedia-Social and Behavioral Sciences, 111, 518-527.

[5] Institute for Transportation and Development Policy (New York, NY)., & Gauthier, A. (2013). *The bike-share planning guide*. ITDP Institute for Planning & Development Policy.

[6] Büttner, J., & Petersen, T. (2011). *Optimising bike-sharing in European cities-a handbook*.

[7] Brian Letwin "These 11 Wonderful Old Maps Show The Evolution Of Saigon And Cho Lon" Saigoneer. Retrieved July 28, 2014, from https://www.saigoneer.com.

Ngày nhận bài: 10/2/2020
Ngày chuyển phản biện: 13/2/2020
Ngày hoàn thành sửa bài: 5/3/2020
Ngày chấp nhận đăng: 12/3/2020