Chapter 17
Evaluation Study on the City Bicycle Rental System

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Abstract Evaluation study on city bicycle rental system plays an extremely important role in the work of the whole city's transportation. The quality and the service level of the rental system's construction will influence the effects of citizens' using it and the improving of the city's transportation problems. However, there still has not a very independent and perfect evaluation system of the public bicycle rental studies so far in China. Based on the principle of selecting index, this thesis is going to divide the evaluation studies on city bicycle rental system into three index systems, namely the rental network design, infrastructure system and management system, by which it can build a scientific and rational evaluation system. By using the Analysis Hierarchy Process (AHP), transacting qualitative index into quantitative index, confirming every index weight, finally there could be a bicycle rental system evaluation value after a comprehensive analysis. Also proceeding an empirical study from the applicative angle to verify the practicality and the feasibility of this article's evaluation theory and method.

Keywords Public bicycle rental system evaluation · Analysis hierarchy process (AHP) · Weight verification · Verify

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17.1 Introduction

With the rapid development of the social economy, citifying process, continuous enlargement of the scale of the city, the rapid growth of population, our city welcome in the unprecedented high speed development time of the motorization. Take Shenzhen for example, motor vehicle population of this city breakthrough 1,700,000 and the annual growth number of vehicle amounts is over 150,000 (Hou 2012).The fact above led the city's transportation problem became more and more important and the problem mainly includes: road resources' saturation, serious traffic jam, the speed of the vehicle is getting slower, the time of the residents trip is getting longer and so on and all of these is becoming the major problem that restrict the development of the city. Meanwhile the huge amounts of the cars brought up the environment pollution and the resources consumption that had a seriously affect the city's ecological environment, social fairness, life quality and sustainable development.

Since 1922, United Nations conference on environment and development had pass 'agenda of twenty-first century', the agenda had promoted 'sustainable development' to a practical objective that we all human beings should pursuit together. Under its theoretical direction, Chris Bradshaw (Su and Luo 2011) brought up the green traffic idea in the 1994 that we should take the green classification to our transportation means and the priority of the classification from high to low followed as walking, bicycle, public transportation and the last is individual automobile driving. The government or the relative company can set couples of the public bicycle rental stations around the city, the citizens or the tourist can rent the bike at any station and give it back at any other stations after finishing using it (Li 2010). It mainly solves the problem like the citizens 'short haul trip', the 'last mile' after the bus and the tourists visiting problem, etc. Moreover it is still an energy-saving, environment protecting and healthy product that can improve the resource utilization ratio remarkably, relief the pressure of the city's transportation jam and reducing the air pollution, lead to a better place for people to live in the city.

17.2 Establishment of City Bicycle Rental System Evaluation

17.2.1 The Principle of Selecting Evaluation Indexes

An accurate evaluation of the bicycle rental system must be based on the index that can fully reflect the usage rate of the public bicycle. The settings of the index system ought to from the actual conditions and should obey the following rules: (a) Scientific and effectiveness character principle. (b) Comparability and

flexibility character principle. (c) The combination of dynamic and static principle. (d) The combination of the qualitative index and the quantitative index principle.

According to the contents of this article, through analysis and combine the character, application scope and the evaluation requirement of the index itself to establish the relevant index system, finally use the confirming of the index weight and Analysis Hierarchy Process (AHP) to calculate all the index value weight so as to confirm the specific level of the evaluation of the bicycle rental system.

17.2.2 Construction of the Evaluation Index System

We should establish a comprehensive and omni-directional evaluation system by cluster analysis that based on all the effective factors of the public bicycle before evaluate the city's bicycle rental system. Based on the functions of the bicycle rental system, it's going to divide the system into three parts, that is, the rental network design, infrastructure system and management system.

The specific evaluation index system of city bicycle rental system shown in Fig. 17.1.

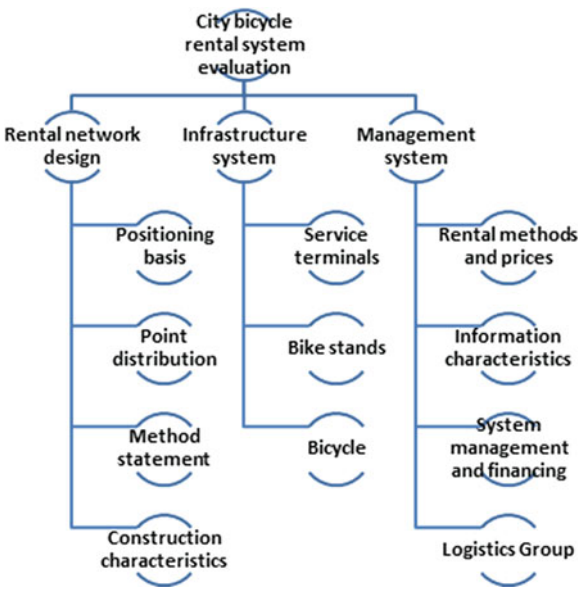

Fig. 17.1 City bicycle rental system evaluation indexes

17.3 The Establishment of the Indexes Weights Based on the AHP

17.3.1 The Overview of Analytic Hierarchy Process

The basic steps to calculate the weight of each index are as follows:

(1) *Building the hierarchical structure*

Based on the investigation and analysis, the range, goals, contained factors and their internal relations of the issue would be figured out. The hierarchical structure could be established.

(2) *Constructing judgment matrix*

By judging a series of twinning factors in each hierarchy, based on certain ratio scale, the judgments were quantified and the comparative judgment matrix was built.

(3) *Determination of hierarchy weights and consistency check*

To measure the reliability and consistency of the evaluation, an index $CR = CI/RI$ was introduced to measure the judgments' deviation. When $CR < 0.10$, the consistency is good.

Each hierarchy index weight could then be $P = \sum_{i,j,k} P_{ijk} \cdot W_{ijk}$ obtained by calculating the weight based on the method shown in the Fig. 17.1.

17.3.2 Comprehensive Evaluation

Corresponding to specific index evaluation criteria, a concrete evaluation conclusion could then be given.

$$\sum_i W_i = 1, \quad \sum_i \sum_j W_{ij} = 1, \quad \sum_i \sum_j \sum_k W_{ijk} = 1$$

where P_{ijk} is the evaluation value of the simple index.

Based on the Table 17.1, by analyzing the evaluation value of the simple index, the detail evaluation of the system in different parts could be obtained. According to the evaluate result, the corresponding countermeasures could be set to improve and enhance the quality of the system.

Table 17.1 City bike rental system evaluation standard

Excellent	Fine	Middling	Qualified	Disqualified
90–100	80–90	70–80	60–70	<60

Table 17.2 Excel algorithm for computing process based on the analytic hierarchy process

City bicycle rental system	Rental network design	Infrastructure system	Management system	According to multiply the line	Open n power	Wi	Awi	Awi/Wi			
Rental network design	1	2	3	6	1.8171	**0.5278**	1.6118	3.0536			
Infrastructure system	1/2	1	3	1.5	1.1447	**0.3325**	1.0153	3.0536	CI=(λ-n)/(n-1)	CR=CI/RI	
Management system	1/3	1/3	1	0.1111	0.4807	**0.1396**	0.4264	3.0536			
					3.4425			3.0536	0.0268	0.0517	
Rental network design	Positioning basis	Point distribution	Method statement	Construction characteristics	According to multiply the line	Open n power	**Wi**	Awi	Awi/Wi		
Positioning basis	1	3	5	7	105	3.2011	**0.5756**	**2 1/3**	4		
Point distribution	1/3	1	3	5	5	1.4954	**0.2689**	**1.1032**	4.1028	CI= (λ-n)/(n-1)	CR=CI/RI
Method statement	1/5	1/5	1	1/2	0.02	0.3761	**0.0676**	**0.2805**	4.1478		
Construction characteristics	1/7	1/5	2	1	0.0571	0.4889	**0.0879**	**0.3592**	4.0853		
						5.5614			4.0985	0.0328	0.0368
Infrastructure system	Service terminals	Bike stands	Bicycle	According to multiply the line	Open n power	**Wi**	Awi	Awi/Wi			
Service terminals	1	2	2	4	1.5874	**0.4934**	**1.5066**	3.0536	CI=(λ-n)/(n-1)	CR=CI/RI	
Bike stands	1/2	1	2	1	1	**0.3108**	**0.9491**	3.0536			
Bicycle	1/2	1/2	1	0.25	0.6299	**0.1958**	**0.5979**	3.0536			
					3.2174			3.0536	0.0268	0.0517	
Management system	Rental methods and prices	Information characteristics	System management and financing	Logistics Group	According to multiply the line	Open n power	**Wi**	Awi	Awi/Wi		
Rental methods and prices	1	1/3	1/4	1/5	0.0167	0.3593	**0.0741**	0.2992	4.0368	CI=(λ-n)/(n-1)	CR= CI/RI
Information characteristics	3	1	3	1/4	2.25	1.2247	**0.2527**	1.2421	4.9163		
System management and financing	2	1/3	1	1/5	0.1333	0.6043	**0.1247**	0.4668	3.7449		
Logistics Group	5	2	5	1	50	2.6591	**0.55**	2.0478	3.733		
						4.8475			4.1078	0.0359	0.0402

Table 17.3 The weights of city bike rental system evaluation index system

Project	Level 1 of evaluation content		Level 2 evaluation content	
	Evaluation index	Weight	Evaluation index	Weight
City bicycle rental system evaluation	Rental network design	0.528	Positioning basis	0.575
			Point distribution	0.269
			Method statement	0.068
			Construction characteristics	0.088
	Infrastructure system	0.332	Service terminals	0.493
			Bike stands	0.311
			Bicycle	0.196
	Management system	0.140	Rental methods and prices	0.074
			Information characteristics	0.253
			System management and financing	0.125
			Logistics Group	0.548

17.3.3 Determination of the System Index Weight

At this thesis, the software Excel was used to calculate the evaluation value of all steps for its powerful operating function (Xian 2012). The simplification of the consistency check and the adjustment of the judgment matrix were realized. The method was called as the Excel arithmetic of the analytic hierarchy process. The calculation results and data of the method were all keep the accuracy of the highest digit and the error was minimized. All steps of the calculation were concise as shown in the Table 17.2.

Table 17.4 the operation process of Excel algorithm based on the AHP.

Then the weight of each evaluation index could be determined as shown in the Table 17.3.

17.4 Case Analysis

From the 1980s to 1990s, most people of Wuhan city use bicycles (3.8 million), other than motors as their daily vehicles. With the rapid devolvement of the economy of the 1990s, more motors ware used to replace bicycles. The number of bicycles in Wuhan city has decreased to 1 million in 2008 (Li et al. 2009). In order to solve the increasingly serious problem of traffic jam, in May 2009, the municipal government of Wuhan City carried out of policy to support the public bicycle rental system, which is very effective. In the thesis, the author gives a comprehensive evaluation of the public bicycle renting system, based on the combination of different index and the usage of leveled analysis, as in Table 17.4.

Table 17.4 Evaluation of PBRS in Wuhan

Item	Level 1		Level 2		
	Index	Value	Index	Conclusion	Value
City bicycle rental system evaluation 82.931	Rental network design	**91.050** (0.528)	Positioning basis	The positioning mentality is total quantity control, classified processing, scale balancing, flexible adjusting. The positioning basis is connected to public transportation, giving service to the short distance and large scale travel	92
			Point distribution	Point distribution mainly for transit point, public point, settlements, recreation point, campus point. Set transit point, public point, campus point as center, the average distance to settlements is less than 300 m	90
			Method statement	Construction manual is relatively perfect, reached the construction design standards	95
			Construction characteristics	Bicycle equipped with diversification, service system point is excessive with big range	85
	Infrastructure System	**80.483** (0.332)	Service terminals	Service terminal facilities are simple. Search function need to be completed	75
			Bike stands	Reasonable designed, the quantity of equipments reach the standard	92
			Bicycle	The bicycle is of convenience, comfort and safety, but lack of management control system device	76
	Management System	**58.118** (0.140)	Rental methods and prices	Residents could open the "Integrity Card" by their ID card for free to rent the bicycle without the rental	95
			Information characteristics	Bicycle information system need to be completed	50
			System management and financing	Operating the company as an enterprise with marketization which benefited by the bicycle body float advertising and carport advertising with indeterminacy for rent. Sources of funds need to be expanded	62
			Logistics group	For less the service hotline, issues of the residents are not resolved in time; Maintenance is not in time, bikes are cumulative loss; Plenty System fault with incomplete stability; have not introduced the wireless network mobile service points yet	56

The value of city bicycle rental system gets 82.931 points in Wuhan. Based on the criterion of Table 17.3, we can say that this is a relatively high value-fine. Specifically, this system has a good designation of network and infrastructure. But there is potential problem in its management system, which need further improvement. The result of the evaluation of city bicycle rental system is in accords with our investment of the real situation, which means that our methods are sound and effective.

17.5 Conclusion

It has been a general tendency and consensus to develop the environmentally friendly public transportation system, such as the bicycle and bus system, and to build their evaluation system. In this thesis, after the consideration the public bicycle system of the main cities in the world, the author chooses the rental grids design, the infrastructure system, the management system as the mean evaluation index. Using analysis hierarchy process, we are able to value the performance of a system in different index precisely, and get a final conclusion by assigning the indexes with different weight. This method not only enables us to analysis the system thoroughly, but also enables us to find the potential problem and come up with an effective solution. And it is a fundamental solution to the city trips "last mile", provide protection for the residents travel, and achieve the fundamental needs of residents of efficient, comfortable, fast, affordable.

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