ISSN: 2414-1895 DOI: 10.6919/ICJE.202009_6(9).0026

Site Selection of Car-sharing Parking Spots

Zhichao Fang

School of Shanghai Maritime University, shanghai 201300, China.

Abstract

The location of car-sharing parking spots is an important issue in the growing car-sharing industry. This paper considers the factors that influence the choice of car-sharing parking spots, Classifying these factors in terms of company, government, users and environment. And based on AHP established a hierarchical model for the site slesction of car-sharing parking spots. The feasibility of the model is verified by the analysis of the arithmetic cases, which can provide a feasible decision basis for the location of car-sharing parking spots.

Keywords

Car-sharing parking spots, Analytic hierarchy process, Site selection.

1. Introduction

In recent years, many cities have implemented policies such as restricted traffic and limited purchases for private cars. The high cost of private cars and the waste of resources caused by low-frequency use have also become increasingly prominent. As an innovative transportation service product, car-sharing was called a revolution in personal transportation, and Car sharing is not only in line with the concept of energy saving, emission reduction, green living, for most users save the vehicle purchase fee, parking fees, maintenance fees, maintenance fees and other costs of private cars,can greatly save costs [1].

The prospect of the car sharing industry is great, but companies are limited by the number and layout of parking spaces and other infrastructures, which makes car sharing difficult at present. It cannot be put into use on a large scale and only a limited number of parking spots can be established [2]. Therefore, it is necessary to formulate a reasonable and effective plan for the location of car-sharing parking spots to increase the usage rate and improve the overall service level of car-sharing. The choice of car-sharing parking sites is also important for optimizing the allocation of urban transportation infrastructure resources and meeting the diverse travel needs of residents.

Considering the existing experience on the site selection problem, the fact that parking spots are affected by many qualitative and quantitative factors, and the incomplete data of each alternative spots, this paper decided to adopt the analytic hierarchy process. This paper divides the related factors into four parts: company, government, users and environment, and constructs a hierarchical structure model to analyze the siting of car-sharing parking spots.

2. Decision-making methods for siting car-sharing parking spots

2.1 Factors influencing the siting of car sharing parking spots

For car sharing company, it's the upfront construction costs that are huge compared to the later management and maintenance costs, and the cost of land to build parking sites in different areas varies. In addition, a reasonable location can avoid excessive competition with other car-sharing companies in the surrounding area, and a location in a densely populated area can also effectively promote the enterprise's brand and reflect the value of the enterprise's brand objectives.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202009_6(9).0026

The choice of city car-sharing spots should be in line with the current policies of the government and refer to the government's long-term planning for the area to be selected to determine whether the location of the parking point is appropriate.

There is also a need to consider the size of users near sharing car parking spots. It is possible to determine the size of the potential users from the passenger flow in the area near the parking spot and the travel demand of people in the nearby area.Areas with heavy flow of people and a strong need for people to travel also have more potential users. In addition, we can judge the coordination between car sharing and public transportation, such as subways and buses, by the convenience of the surrounding public transportation. The better the coordination, the more convenience and efficiency in using car sharing for travel, the more users will be attracted.

Finally, the creation of parking spots also has an impact on the environment.It can be divided into impacts on the transport environment and impacts on the natural environment. The impact on the traffic environment includes relieving the pressure on the surrounding road traffic and increasing the number of parking spaces in the parking area. Impacts on the natural environment, including damage to vegetation greenery and urban landscapes.

2.2 The hierarchical model for selecting parking spots

In order to divide the influencing factors of complex problems into related ordered levels and make them orderly, it is necessary to establish a hierarchical structure model [3]. To divide the relevant factors that affect the site selection model, the selection and division of indicators should take into account the principles of scientificity, objectivity, feasibility, comparability, and practicability. The model is divided into target layer, criterion layer and indicator layer. There are 10 indicators in the indicator layer, as shown in the figure1.

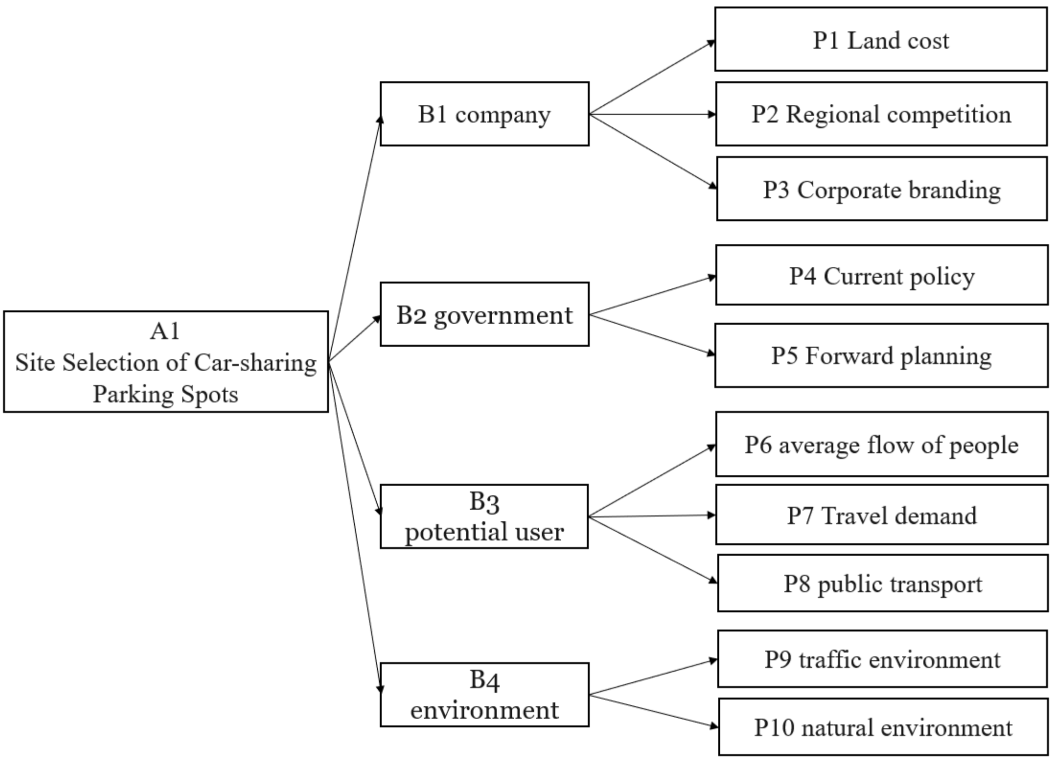

Figure 1. The hierarchical model

2.3 Weighting of indicators

The pairwise comparison judgment matrix A is constructed using the following method. Set the judgment matrix as $A=(a_{ij})$ $(i,j=1,2,\dots,n)$, where a_{ij} denotes the relative importance of indicator i to indicator j,and $a_{ij}>0$, $a_{ij}=1/a_{ji}$, $a_{ii}=1$. The method for value determination is shown in Table 1.

ISSN: 2414-1895 | DOI: 10.6919/ICJE.202009_6(9).0026

Table 1. Meaning of scales

a_{ij} scale	Importance judgment
1	The two factors have equal importance
3	The former factor is more important than the latter factor
5	The former factor is obviously more important than the latter
7	The former factor is strongly more important than the latter
9	The former facto indicator r is extremely more important than the latter
2,4,6,8	Other intermediate values are between two adjacent
Reciprocal	Contrary to the foregoing

Consistency check to ensure accuracy of calculations, consistency ratio (C.R.) is calculated as

$$CR = \frac{CI}{RI} \tag{1}$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2}$$

When C.R.<0.1, then consider that the matrix satisfies the consistency test; when C.R.⩾0.1, the judgment matrix has to be corrected.The R.I. is shown in Table 2.

Table 2. Random index

n	1	2	3	4	5	6
RI	0	0	0.58	0.90	1.12	1.24

After thorough research and consultation with relevant experts, the judgment matrix of each factor is derived, and the weights of each factor are calculated through the appeal step, and the process and results are shown in Tables 3-7 below.

Table 3. Target-Level Judgment Matrix and Weights

A	B1	B2	B3	B4	weight
B1	1	2	1	3	0.3507
B2	1/2	1	1/2	3/2	0.1892
B3	1	2	1	3	0.3507
B4	1/3	2/3	1/3	1	0.1093

C.R.=0.0039<0.1, meet consistency.

Table 4. B1 Judgment Matrix and Weights

B1	P1	P2	P3	weight
P1	1	2	4	0.5714
P2	1/2	1	2	0.2857
P3	1/4	2	1	0.1429

C.R.=0<0.1, meet consistency.

Table 5. B2 Judgment Matrix and Weights

B2	P4	P5	weight
P4	1	3	0.75
P5	1/3	1	0.25

C.R.=0<0.1, meet consistency.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202009_6(9).0026

Table 6. B3 Judgment Matrix and Weights

B3	P6	P7	P8	weight
P6	1	3	4	0.6232
P7	1/3	1	2	0.2395
P8	1/4	2	1	0.1373

C.R.=0.0158<0.1, meet consistency.

Table 7. B4 Judgment Matrix and Weights

B4	P9	P10	weight
P9	1	3	0.75
P10	1/3	1	0.25

C.R.=0<0.1, meet consistency.

It can be seen from the calculations that all the judgment matrices satisfy consistency and that all the weights obtained for each factor are reliable. The weight of sub-indicator layer P on target layer A (W_P) can be calculated by calculating the weights of the influencing factors in each judgment matrix,W_P=(0.2004, 0.1002， 0.0501， 0.1419， 0.0473， 0.2186， 0.0840， 0.0482， 0.0820， 0.0273)^T.

2.4 Make evaluation decision model

Establishment of a judgement matrix for each factor in the different options through scoring and data comparison,

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1j} \\ r_{21} & r_{22} & \cdots & r_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ r_{k1} & r_{k2} & \cdots & r_{kj} \end{pmatrix} \tag{3}$$

Where r_{kj} represents initial scoring value for indicator j in scenario k , Standardization of the initial values of the factor indicators according to formulae.

$$r_{kj}^{*} = \frac{r_{kj} - \min(r_{1j},\ r_{2j},\ \cdots r_{kj})}{\max(r_{1j},\ r_{2j},\ \cdots r_{kj}) - \min(r_{1j},\ r_{2j},\ \cdots r_{kj})} \tag{4}$$

Finally, by the evaluation decision-making formula shown below, the combined weight vector ω is obtained.Compare the score vectors corresponding to each scheme in ω to determine the size of the evaluation index value and select the better scheme.

$$\omega = W_p\ R^{*} \tag{5}$$

3. Case Analysis

According to the main travel purpose of urban residents (work, school, shopping, leisure and return travel account for about 85% of the total travel), the points of interest are correspondingly divided into 5 categories: education, leisure, residence, work, shopping, etc [4]. Select five different locations S1, S2, S3, S4, S5 near large shopping malls, near universities, residential areas, tourist scenic areas, and CBD, respectively. The four sites are analyzed and evaluated and scored on the four indicator factors: business, government, user and environment. Where land cost (P1), average pedestrian flow (P6), and public transport (P8) use statistical data as reference criteria; The degree of regional competition (P2), corporate branding (P3), current policy (P4), long-term planning (P5), travel demand (P7), transport environment (P9), and natural environment (P10) are scored by experts as criteria.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202009_6(9).0026

After completing the scoring, it is standardized according to the formula, and each standardized value for the final location Si is calculated by the corresponding indicator weight. The combined weighted values are compared. The process and results of the calculations are shown below.

The judgement matrix for each factor in the different options:

$$R = \begin{pmatrix} 9 & 0 & 9 & 7 & 7 & 8 & 9 & 8 & 6 & 5 \\ 6 & 9 & 7 & 8 & 7 & 7 & 8 & 8 & 5 & 5 \\ 5 & 0 & 5 & 6 & 4 & 5 & 7 & 6 & 2 & 6 \\ 6 & 0 & 6 & 7 & 8 & 6 & 9 & 4 & 5 & 7 \\ 9 & 9 & 8 & 7 & 7 & 7 & 9 & 8 & 5 & 6 \end{pmatrix}$$

The matrix after standardization:

$$R^* = \begin{pmatrix} 0 & 1 & 1 & 0.5 & 0.75 & 1 & 1 & 1 & 1 & 1 \\ 0.75 & 0 & 0.5 & 1 & 0.75 & 0.66 & 0.5 & 1 & 0.5 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0.5 & 0 & 0.5 \\ 0.75 & 1 & 0.25 & 0.5 & 1 & 0.33 & 1 & 0 & 0.5 & 0 \\ 0 & 0 & 0.75 & 0.5 & 0.75 & 0.66 & 1 & 1 & 0.5 & 0.5 \end{pmatrix}$$

Obtained from the formula (5), $\omega=(0.7167, 0.6554, 0.3383, 0.5783, 0.4751)^{T}$.

Ranking of the scores corresponding to the four different scenarios according to the calculated results, S3<S5<S4<S2<S1. The comparison shows that it is best to set up car sharing parking spots at the S1 location near the large shopping mall, and S3 locations near residential areas are relatively least suitable for setting up car sharing parking spots.

4. Conclusion

Only a ridesharing network plan that is adapted to the local city can make the company stand out from the competition. At present the car sharing industry is still in the development stage, reasonable and suitable parking points can enable companies to quickly capture the market and effectively enhance the competitiveness of companies [5]. This paper establishes a hierarchical model of car sharing parking site selection using hierarchical analysis, and takes the problem of car-sharing parking site selection as a system, transforming the decision-making problem which is difficult to quantify into a multi-level single-objective problem. And the results obtained in the analysis of the examples are more in line with the actual situation, which proves that the model is practical and reference. However, some of the factor indicators in this article lack the support of actual data and have certain errors. In the actual problem, the company has a larger candidate area and more candidate points. To solve these problems, further research and learning are needed.

References

[1] Edourad Serot, Yang fan. Research of the Location Selection of Car Sharing Station of Electric Vehicle. Shanghai Auto, 2013(07):32-35+39.

[2] Dong Jing, Changzheng Liu, Zhenhong Lin. Charging infrastructure planning for promoting battery electric vehicles: An activity-based approach using multiday travel data. Transportation Research Part C: Emerging Technologies 38 (2014): 44-55.

[3] Jihong Chen, Zheng Wan, Fangwei Zhang, Nam-kyu Park. Evaluation and comparison of the development performances of typical free trade port zones in China. Transportation Research Part A,2018,118.

[4] SUN Lishan, WANG Shunchao, LUO Wei, YAO Liya, WANG Kun. Car-Sharing Demand Estimation Model Based on Land Use Distribution Characteristics. Journal of Chongqing Jiaotong University (Natural Science), 2020,39(05):1-6.

[5] ZHAO Junli, RAN Wenxue. The Decision Making of Urban Shared Car Parking Site Selection Based on Gray Fuzzy Analysis. Logistics Engineering and Management. 2020,42(01):103-106+109.