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Research Article

Cloud Improvement Model of Niche Width and Its Application in Tram Evaluation

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Niche theory is one of the most important theories and tools in ecology. Niche width is a concept used to measure the position and role of an individual or population in a biological community. However, in the measurement of niche width, due to the unique characteristics of ecosystems, evaluators often give information based on subjective judgment to describe the status of ecological factors. Natural language is used to describe the state of ecological factors, and all the observed values come from the subjective judgment of the language value of the evaluator and have fuzziness and randomness at the same time. To achieve scientific and reasonable decision evaluation, it is necessary to comprehensively consider the fuzziness and randomness of complex systems. The cloud model is used to improve the niche width model, aimed at solving ecological factors under natural language information assignment and niche width evaluation. It is applied to measure tram niche width, which is the typical ecological factor value assignment using natural language thinking.

1. Introduction

Niche theory is one of the most important theories and tools in ecology. To date, the application of niche theory has expanded to various disciplines and is increasingly used in nonlife fields, such as nontraditional ecological fields such as politics, economy, industry, agriculture, culture, architecture, and education, and even transportation niche analysis [1], thus forming powerful theoretical tools [2–7]. Hutchinson [8] proposed the concept of niche width to measure the status and role of individuals or populations in biomes. The greater the niche width values are, the more fully the individual or population uses various resources, making it easier to be in a dominant position in the community. However, in the measurement of niche width, due to the unique characteristics of the ecosystem, evaluators often give information based on subjective judgment to describe the state of ecological factors. Therefore, many scholars propose using the fuzzy sets theory to solve this problem. Among them, Ragade believes that fuzzy sets theory provides technical support for ecosystem decision-making [9]. Bosserman used fuzzy sets theory to study the problem of niche classification based on expert knowledge [10]. W. Wang used fuzzy sets theory to discuss the ecological concepts of community hierarchy and dominant species, community crisscross regions, similarity metrics, and the relationship between niches and communities [11]. G. Cao addresses the limitations of the Hutchinson niche concept and proposes a new concept of a fuzzy niche [12]. F. Hao and Y. Li, on the other hand, developed niche theory and proposed the concept of a fuzzy supervolume niche and the measurement formula of niche width and niche overlap [13].

In addition to fuzzy sets theory, solutions to similar problems also exist in probability and mathematical statistics, rough sets, and other theories. These methods have clear entry point and clear boundary condition constraints, which are easy to operate, but they often have certain limitations. For example, probability and mathematical statistical theory often need the determination of prior probability, requiring a large amount of data as the foundation. Rough set theory also has a certain generality. These methods adopt hard boundary division when dealing with the boundary problem of the data. This advantage is that the data differentiation degree is good, but also means that the ambiguity and randomness of the data are correspondingly reduced. However, the evaluator uses natural language to describe the state of ecological factors. All the observed values come from the subjective judgment of the language value of the evaluator, and it also has ambiguity and randomness. To achieve scientific and reasonable decision evaluation, we must comprehensively consider the ambiguity and randomness of complex systems. Therefore, according to the subjective evaluation of the language value, the traditional fuzzy sets, probability, and mathematical statistics and rough sets are no longer objective and comprehensive responses to the actual situation to a certain extent. D. Li proposed a new idea of subordinate clouds, using digital characteristics to describe subordinate clouds, and pointed out that normal subordinate clouds have universality in a large number of fuzzy concepts [14]. Later, Z. Yang, K. Di, and others further proposed extending the two-dimensional cloud and the multidimensional cloud for the knowledge expression and prediction of the spatial database [15, 16]. D. Li also applied the multidimensional cloud model to explore the association rules [17] from the spatial database, further extending the application of the cloud model. With the development of research, D. Li pointed out the normal cloud model through expectation, entropy, and super entropy, the precise determination of the membership function to construct the normal membership distribution, the normal distribution formation condition is more relaxed, its universality is stronger, and the situation between qualitative and quantitative interconversion is simpler and more direct [18]. C. Liu defined the expectation curve of the normal cloud model, analyzed the trend and law of the normal cloud model with parameters, further explained the universality of the normal cloud model, and further revealed the rationality of the concept of cloud model representation uncertainty [19]. In terms of the reverse cloud algorithm, C. Liu proposed a simpler and more accurate reverse cloud algorithm to reduce the error [20]. H. Chen proposed a new reverse cloud algorithm without certainty, which solves the problem of occasional hyperentropy of existing reverse cloud algorithms [21]. At the same time, the emergence of cloud reasoning [22], similar clouds [23], and other concepts has continuously improved cloud model theory itself, and its application in intelligent control and prediction, data mining, risk warning, system evaluation, and other fields is also more profound [24–27]. Therefore, the cloud model to improve the measurement model of niche width aims to solve the problem of ecological factor assignment and niche width evaluation under natural language information and applies to the typical tram niche width evaluation of ecological factor assignment.

2. Cloud Model Theory

The cloud model is used to realize the natural transformation of the uncertain language value and the quantitative value. The theory comes from the classical random theory and fuzzy sets theory, but the relatively fuzzy sets theory has the advantages of reflecting the randomness and ambiguity and the correlation between them, forming a qualitative and quantitative mapping, greatly avoiding the uncertainty in the decision-making process.

2.1. Cloud and Cloud Drops. Let U be a quantitative domain expressed by exact values, C is a qualitative concept on U, if the quantitative value $x \in U$, and x is a random implementation of the qualitative concept C, the certainty of x to C is a random number with a stable tendency

$$\mu : U \longrightarrow [0, 1] \forall x \in U x \longrightarrow \mu(x). \tag{1}$$

The distribution of x in the theoretical domain U is called a cloud, and each x is called a cloud drop [28]. In fact, cloud is a holistic description of multiple cloud droplets. The description employs three digital features: expected value Ex, entropy En, and hyperentropy He. Using these three digital features of the cloud can transform qualitative concepts into quantitative expressions, enabling efficient integration of qualitative conceptual ambiguity and randomness. Cloud model has the following properties:

Cloud model is a distribution of random variables x in the quantitative field U, and $x$has the certainty of the nature of random variables.

Cloud model consists of multiple cloud drops. Every realization of the random variables x in the qualitative concept is a cloud drop, and the whole composed of multiple cloud drops is a cloud.

Cloud drops have the certainty of the nature of random variables, which refers to the degree to which the cloud drops can reflect this qualitative concept.

2.2. One-Dimensional Normal Cloud. The normal cloud model is the most basic morphology in the cloud model. According to probability theory, the expected curves of a large number of random distributions approximately obey a normal distribution, both in the social sciences and in the natural sciences.

Let U be a quantitative domain expressed by exact values, C is a qualitative concept on U, if the quantitative value $x \in U$, and x is a random implementation of the qualitative concept C, if x satisfies $x \sim N(Ex, En'2)$, where $En' \sim N(En, He^2)$, and the certainty of x to C satisfies

$$\mu = e^{-(x-Ex)^2/2\left(En'\right)^2}. \tag{2}$$

The distribution of x over the theoretical domain U then becomes a normal cloud. In general, a normal cloud is universal to uncertain knowledge representations [29]. The normal cloud model constructs specific algorithms based on the normal distribution in the probability theory and the Gaussian membership function in the fuzzy sets to realize the qualitative and quantitative uncertainty transformation. Hyperentropy He is a measure of the degree of deviation from the normal distribution and can reflect the inequality in the influencing factors or whether they are not independent of each other. When $He=0$, the cloud model degenerates to a normal distribution, and the certainty degenerates to a classical normal membership function. The universality of the normal distribution and the universality of the normal membership function together lay the theoretical basis for the universality of the normal cloud model. Therefore, all the clouds in this manuscript also obey a normal distribution.

2.3. Forward Cloud Generators and Reverse Cloud Generators. The algorithm that generates cloud droplets is called a cloud generator. According to the cloud generation mechanism and computing direction, the cloud generator can be divided into a forward cloud generator and a reverse cloud generator. Forward cloud generators are different from reverse cloud generators in that different known conditions lead to different results. A forward cloud generator generates normal cloud-distributed cloud droplets $\mathrm{Drop}(u_i, v_i)$ based on three known digital features. The reverse cloud generator refers to a set of cloud droplets given one conforming to the law of a certain normal cloud distribution as a sample, producing three digital characteristics, that is, Ex, En, and He, and describing the qualitative concepts corresponding to the cloud.

2.4. The 3En Criterion for the Cloud Models. The $3En$ criterion for the cloud model means that for qualitative concept C in quantized domain U, the contributing quantitative values fall mainly within the interval $[E_x - 3E_n, E_x + 3E_n]$, where the cloud drop elements are small probability events that are negligible. Therefore, when using the cloud model to achieve qualitative to quantitative transformation, the cloud droplets outside this interval can be ignored, thus reducing the computational complexity.

3. Cloud Improvement Model of Niche Width

3.1. Niche Width Model

3.1.1. Niche Resource Matrix. The niche resource matrix represents the number of biological individuals or populations that occupy or utilize niche resources. According to the niche hypervolume composition, the niche space composed of the niche is composed of various ecological factors designed to satisfy the survival and development of an individual or population. These ecological factors are the resource conditions required for the survival and development of individuals or populations, and there is a certain range of threshold values. In terms of various resource conditions, the measured value of ecological factors indicates the degree of satisfaction with the survival and development and ecological value of individuals or populations. Thus, the niche resource matrix is shown in Table 1.

In Table 1, D_j represents the j-dimensional ecological factor of biological individuals or populations; S_k represents the resource gradient of the biological individual or population on the j-dimensional ecological factor; and P_{ik} represents the proportion of the i-th biological individual or population occupying the k-th ladder resource on the j-dimensional ecological factor.

3.1.2. Basic Model of Niche Width. Initially, the concept of niche width [30] was proposed by Hutchinson. Van considers niche width as the proportion of resource-limited multidimensional space exploited by a species or community segment [31]. Macarthur and Levins extend it further [32, 33], arguing that niche width is actually the distance passing along a particular line in niche space. In fact, so-called niche width refers to the sum of the different resources occupied and utilized by an organismal unit. Here, the Levins formula [33, 34].

$$B_{ij} = 1/\sum_{k=1}^{r}(p_{ik})^2 (i = 1, 2, \cdots, n\,; j = 1, 2, \cdots, m\,; k = 1, 2, \cdots, r), \tag{3}$$

$$P_{ik} = N_{ik}/\sum_{k=1}^{r} N_{ik} (i = 1, 2, \cdots, \mathrm{n}\,; k = 1, 2, \cdots, r). \tag{4}$$

B_{ij} represents the niche width index of individual or population i on resource dimension j. j represents the evaluation index dimension of the niche, i represents the number of objects evaluated, k represents the niche resource gradient, and P_{ik} represents the proportion of the i-th biological individual or the population on the j-th dimension ecological factor. In general, the value of P_{ik} is obtained by the ratio of the number of individuals (N_{ik}) to the total number of individuals connected between the biological individual or the population i and the k-th gradient of the evaluation index j.

The niches of biological individuals or populations generally have multidimensional ecological factors with different weights, reflecting the influence and importance of each ecological factor on the biological individual or population niche. Multidimensional niche width measurements can be obtained by the one-dimensional niche width exponential weighting included. Therefore, the multidimensional niche width formula is as follows:

$$B'_{ij} = \sum_{j=1}^{m}\left(W_j \times B_{ij}\right)(i = 1, 2, \cdots, n\,; j = 1, 2, \cdots, m), \tag{5}$$

where i represents the biological individual or population, j represents the index dimension, $B^{`}_{ij}$ represents the niche width of the biological individual or population i, and W_j represents the weight of index j.

3.2. Cloud Improvement Model of Niche Width

3.2.1. Cloud Conversion. For the evaluation value conferred by a group of multiple evaluators with natural language information, the resulting data need to be converted into qualitative concepts. Here, the reverse cloud occurrence algorithm is used to obtain three digital eigenvalues, thus realizing the cloud transformation of the sample data. A

Table 1: Niche resource matrix.

			D_1		…		D_j		…
		S_1	…	S_k	…	S_1	…	S_k	…
	1	$P_{11}(D_1)$	…	$P_{1k}(D_1)$	…	$P_{11}(D_j)$	…	$P_{1k}(D_j)$	…
	2	$P_{21}(D_1)$	…	$P_{2k}(D_1)$	…	$P_{21}(D_j)$	…	$P_{2k}(D_j)$	…
Biological	…	…	…	…	…	…	…	…	…
	i	$P_{i1}(D_1)$	…	$P_{ik}(D_1)$	…	$P_{i1}(D_j)$	…	$P_{ik}(D_j)$	…
	…	…	…	…	…	…	…	…	…
	n	$P_{n1}(D_1)$	…	$P_{nk}(D_1)$	…	$P_{n1}(D_j)$	…	$P_{nk}(D_j)$	…

reverse cloud generator refers to a set of cloud droplets given a certain normal cloud distribution rule as a sample, producing three digital features Ex, En, and He and describing the qualitative concepts corresponding to the cloud. Among them, the reverse cloud generator [22] is.

Step 1. Calculate the average of known cloud droplets, which is the expected value of the reverse subordinate cloud model.

$$Ex = \frac{1}{n}\sum_{i=1}^{n} x_i. \tag{6}$$

Step 2. Calculate the entropy belonging to the cloud model.

$$En = \sqrt{\frac{\pi}{2}}\frac{1}{n}\sum_{i=1}^{n}|x_i - Ex|. \tag{7}$$

Step 3. Calculate the hyperentropy belonging to the cloud model.

$$H_e = \sqrt{S^2 - En^2} = \sqrt{\frac{1}{n-1}\cdot\sum_{i=1}^{n}(x_i - \bar{x})^2 - En^2}. \tag{8}$$

Step 4. If $S^2 - En^2 < 0$, delete the sample of 1% near the expected value and return to step 3.

At this point, the cloud of the niche observed for the biological individual or population i on a one-dimensional resource is expressed as C_i (Ex_i, En_i, He_i).

3.2.2. Cloud Improvement Model. The cloud expression of the observed niche of a biological individual or population i on a one-dimensional resource is $C(Ex, En, He)$. For example, the one-dimensional normal cloud C (3.07, 0.68, 0.43) and the cloud model for niche width evaluation were analyzed, as shown in Figure 1.

In the basic model of niche width, P_{ik} represents the proportion of the biological individual or population i in the k -th gradient state of the resource dimension j and is the ratio of the total number of individuals (or other indicators) connecting the biological individual or population i to the k -th gradient of the resource dimension j. However, in practice, the number of connected individuals is based on subjective judgment and cannot be completely accurately determined, and the proportion of the evaluation object in the k-th gradient state is determined by the ratio of the number of connected individuals to the total number of individuals only, and there is also error.

C. Liu demonstrated that the cloud drop of normal clouds is a random variable, in which the expected value is Ex and the variance is $En^2 + He^2$ [19], so the niche of a biological individual or population in one dimension is in the form of a normal cloud. Then, the proportion of a biological individual or population i and the k-th gradient state of resource dimension j can be expressed by the area under the normal distribution curve, that is, the probability of the object in a certain gradient interval. Then, the values of P_{ik} can be calculated using a standard normally distributed area surface query. For example, in Figure 1, when the resource gradient of this ecological factor is 4, the proportion that the biological individual or population occupies over the [4, 5] gradient interval on this dimension can be approximated by the proportion of the [4, 5] interval area under the maximum expectation curve of the normal cloud to the [1, 5] interval area under the maximum expectation curve.

In the practice of niche width evaluation, the normal distribution of its niche is not always standard normal $\delta \sim N(0, 1)$, and it needs to adopt a standardized formula to standardize some parameters and then solve the normal distributed area surface. Let the one-dimensional niche cloud model of a biological individual or population be $C(Ex, En, He)$. P_{ik} is the proportion of the cloud model and the population on the resource gradient k based on the relationship between the cloud model and the normal distribution, that is, the probability of a biological individual or population niche in the interval $[k-\omega, k+\omega]$, where ω is the interval parameter of the resource gradient, as determined by the actual situation of the gradient setting.

If $k - \omega > Ex$, point $k + \omega$ and point $k - \omega$ are standardized.

$$U^{+} = \frac{(k+\omega) - Ex}{En^2 + He^2}, \tag{9}$$

$$U^{-} = \frac{(k\text{-}\omega) - Ex}{En^2 + He^2}, \tag{10}$$

$$p_{(k+\omega)} = p_{(-\infty<k+\omega)} = p_{(-\infty<U^{+})}, \tag{11}$$

$$p_{(k\text{-}\omega)} = p_{(-\infty<k\text{-}\omega)} = p_{(-\infty<U^-)}. \tag{12}$$

If $k + \omega < Ex$, point $k + \omega$ and point $k - \omega$ are standardized.

$$U^+ = \frac{Ex\text{-}(k+\omega)}{En^2 + He^2}, \tag{13}$$

$$U^- = \frac{Ex\text{-}(k\text{-}\omega)}{En^2 + He^2}. \tag{14}$$

According to the symmetry of the curve, there are

$$p_{(k+\omega)} = p_{(U^+<\infty)} = p_{(-\infty<-U^+)}, \tag{15}$$

$$p_{(k\text{-}\omega)} = p_{(U^-<\infty)} = p_{(-\infty<-U^-)}. \tag{16}$$

By querying the normally distributed area table, the values of $p_{(k+\omega)}$ and $p_{(k\text{-}\omega)}$ are obtained, and by normalization, the proportion of urban trams on resource gradient k is

$$p_{ik} = \frac{\left|p_{(k+\omega)} - p_{(k\text{-}\omega)}\right|}{\sum_{k=1}^{m\text{-}1}\left|p_{(k+\omega)} - p_{(k\text{-}\omega)}\right|}. \tag{17}$$

Finally, the single dimension niche width index has the same formula (7), and the multidimensional niche width index has the same formula (9).

4. Application in Tram Evaluation

Trams cannot be separated from the city, a composite ecosystem of nature, economy, and society. A city not only involves the natural environment, including geological and climate elements, but also involves human production, life, economic development, and civilization interaction, with a country or region of political, economic, and science and technology cultural center function, which is a kind of by nature, society, culture, political, economy, behavior, and other factors under the comprehensive influence of the overall environment. Different cities have obvious differences due to their urban economic ability, geographical environment, culture, customs, and many other factors. People have different demands for the psychological feelings, functional expectations, and aesthetic demands of trams, and their essence comes from the complex urban ecosystem itself. The sustainable development and modernization process of trams must be on the basis of paying attention to the development of nature, society, culture, politics, economy, behavior, and other factors, put people first, adapt measures to local conditions, and coordinate with the ecological environment.

Niche theory can use the idea and method of ecology to analyze the tram of the public passenger transport ecosystem and the urban ecosystem and explore the relationship between the tram and its carrying environment. The ecological factor of the tram niche, namely, the resource dimension and the threshold range that it occupies, jointly determines the niche width of the tram. The tram niche width model is mainly used to evaluate the utilization or occupation of ecological factor resources of trams, to evaluate the size of the ecological niche, and to reflect the diversity of ecological factors of trams. Introducing the niche width measurement model into the study of trams will help us to correctly understand the relationship between trams and the carrying environment, reveal the extent to which trams occupy ecological resources, and guide the design of trams from the overall height of the system.

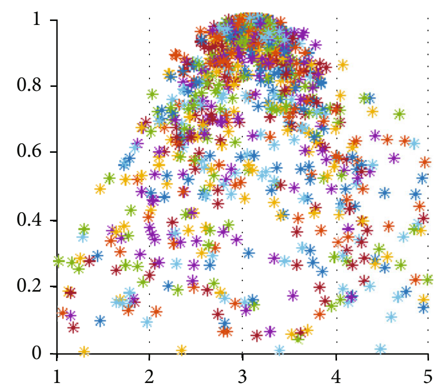

Figure 1: The distribution of a one-dimensional normal cloud on the resource gradient.

4.1. Tram Niche Indicator System. The concept of ecology, one of which the most important foothold is people and the service object of passengers, also determines the survival and development of trams. Therefore, it attaches great importance to the subjective feelings of passengers, takes this as a holistic basis, transforms some ecological factors into scientifically quantified indicators, and becomes the key to communicating the positive relationship between passenger subjective satisfaction and the evolution of the tram niche. Therefore, the author proposed using the text content analysis method, conducting the content analysis of the multi-source large sample data, extracting the core elements, using the Delphi method to design passenger-oriented questionnaires, and finally using factor analysis to build the tram niche indicator system [34], as shown in Table 2.

It should be noted here that the research data of this indicator system are from Chengdu, China. We distributed a total of 240 survey questionnaires along the Chengdu tram line, with 233 recovered and 228 valid questionnaires and an effective rate of 95%. All of the participants in this questionnaire survey had taken trams. Using the KMO test and the Bartlett spherical test on the sample data using SPSS 25.0, the KMO statistic was 0.904>0.9, and the concomitant probability was 0.000, less than the significance level of 0.05, indicating that the validity of the questionnaire is good and suitable for factor analysis. Therefore, the establishment of this indicator system is reliable, but its scope of application is mainly in China.

4.2. Data Research and Acquisition. Using the Likert level 5 scoring scale, the "tram niche width evaluation questionnaire" was compiled based on the tram niche index system, from 1 to 5 being very bad, bad, average, good, and very

Table 2: Tram niche indicator system.

Target layer	Criterion layer	Index layer	Weight
Tram niche A	Functional technology B1	Track structure C1	1.72%
		Braking ability C2	4.03%
		Power performance C3	2.27%
		Run stationary C4	1.72%
		Safety performance C5	4.49%
		Weather resistance C6	1.98%
		Bogie structure and floor height C7	2.91%
		Power supply mode C8	3.62%
	Vehicle environment B2	Station planning C9	4.49%
		Thermal environment C10	2.58%
		Spatial scale C11	6.52%
		Luminous environment C12	1.45%
		Interior decoration C13	2.17%
		Column handrail C14	2.58%
		Plane layout C15	5.69%
		Acoustical environment C16	3.11%
	Operation management B3	Passenger cost C17	0.77%
		Operating time C18	2.53%
		Passenger transport organization C19	6.03%
		Broadcast and information system C20	3.04%
		Facility operation and maintenance C21	2.28%
		Running speed C22	2.90%
		Integration of public transport system C23	3.99%
	Cultural image B4	Track landscape C24	1.66%
		Body shape design C25	1.41%
		Regional visual coordination C26	3.39%
		Passenger visual field C27	0.71%
		Color painting C28	1.90%
		Station shape design C29	1.19%
		Regional cultural integration C30	1.49%
		Material quality C31	0.95%
	Economic suitability B5	Passenger time efficiency C32	2.72%
		Fatigue reduction benefit C33	1.08%
		City size matching C34	3.25%
		Regional economic matching C35	3.25%
		Right-of-way setting C36	4.16%

good, respectively. A total of 150 questionnaires were distributed along Chengdu Tram Line 2, 100 questionnaires were distributed to teachers and students in transportation, mechanical design, and other related majors of Southwest Jiao Tong University, a total of 250 questionnaires were distributed, a total of 220 were recovered, 220 valid questionnaires were recovered, and the questionnaire was 88%. To compare and analyze the niche width of the trams, 220 questionnaires of road bus No. 708 were collected on site along road bus No. 708, and a total of 197 valid questionnaires were recovered.

4.3. Cloud Conversion of the Data. Three digital eigenvalues can be obtained by using a reverse cloud generator to survey statistical data. According to 220 valid questionnaires in the preliminary investigation, the observed ecological niche of Chengdu Tram Line 2 in one-dimensional resources consists of 220 samples. The 220 samples were treated as 220 cloud droplets, which were transformed into cloud model expressions using a reverse cloud generator to generate three digital features describing the corresponding qualitative concepts of clouds, and the cloud expression of Chengdu Tram Line 2 in one-dimensional resources is C_i (Ex_i, En_i, He_i).

4.4. Niche Width Evaluation of Chengdu Tram Line 2. The survey statistics are assigned by the scoring method of 1-5, so the niche dimension of Chengdu Tram Line 2 is divided

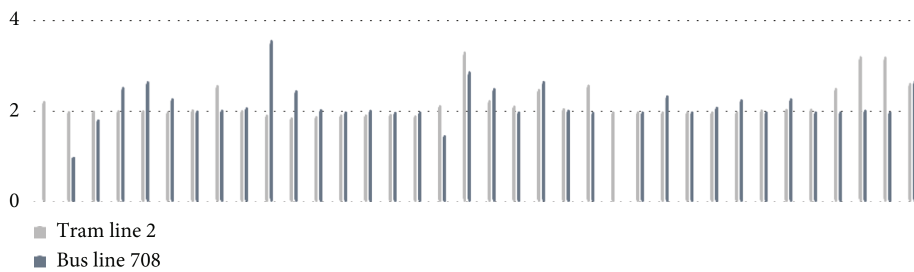

Figure 2: One-dimensional niche width of the Tram Line 2 line and Bus Line 708.

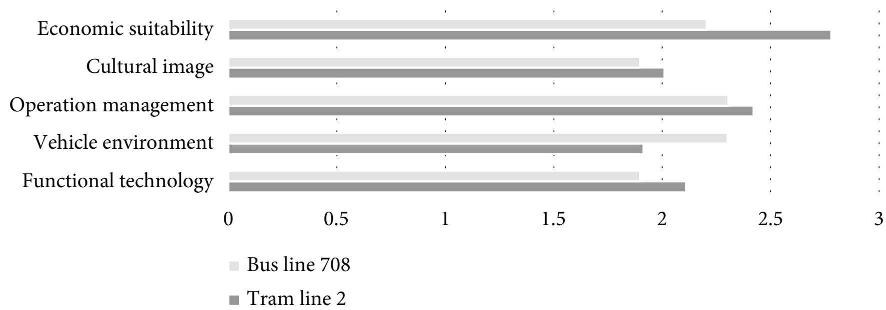

Figure 3: Niche width of Tram Line 2 and Bus Line 708 on criterion layer.

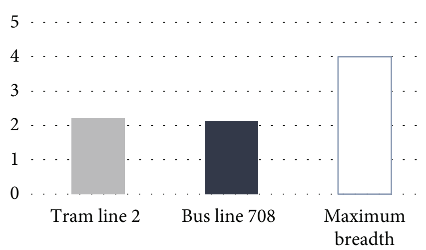

Figure 4: Comprehensive dimension niche width of Tram Line 2 and Bus Line 708.

into four resource grade states, and the niche width of Chengdu Tram Line 2 is 4 at the maximum. According to the cloud expression of the observed values of each index of Chengdu Tram Line 2, the one-dimensional niche width of Chengdu Tram Line 2 and Bus Line 708 is calculated as shown in Figure 2. The niche width of Chengdu Tram Line 2 on the criterion level index is calculated, as shown in Figure 3. Finally, the calculated comprehensive dimension niche width value of Chengdu Tram Line 2 is 2.214, while the comprehensive dimension width value of Bus Line 708 is 2.127, as shown in Figure 4.

5. Conclusion and Discussion

The main conclusions are as follows:

The capacity of Tram Line 2 to occupy niche resources is average. The niche width of Tram Line 2 in most dimensions is approximately 2, and the average value is 2.198, while the comprehensive dimension niche width value is only 2.214, which is quite different from the maximum niche width value of 4. This shows that Tram Line 2 has an average ability to occupy niche resources in the region.

Tram Line 2 has high demand generalization in three dimensions: Operating Time, City Size Matching, and Regional Economic Matching. The niche width of Tram Line 2 in three dimensions, Operating Time, City Size Matching, and Regional Economic Matching, all exceeds 3, which shows that Tram Line 2 occupies a large range of these resource gradients, the respondents have high generalization of demand for these three dimensions, and their understanding is not uniform. Tram Line 2 occupies high ecological resources in these three dimensions, so it has great potential for survival and competition.

Tram Line 2 occupies a strong demand specialization in the Thermal Environment, Spatial Scale, Interior Decoration, and other dimensions. The niche width values of Tram Line 2 in Vehicle Environment dimensions such as Thermal Environment, Spatial Scale, and Interior Decoration are all lower than 2, which shows that people's opinions on Tram Line 2 in Vehicle Environment dimension tend to be consistent, and Tram Line 2 occupies a small resource gradient in Vehicle Environment dimension, with strong selectivity to ecological resources and strong niche specialization. This is consistent with the actual state. At the same time, this is related to the specialization of the respondents' demand for trams in these dimensions.

There were differences in the utilization of ecological resources in the different criterion layers of Tram Line 2. Tram Line 2 has the highest niche width in the dimension of Economic Suitability, which shows that the utilization ability of Economic Suitability ecological factor resources is obviously generalized, and the demand provided by Economic Suitability ecological factor resources for Tram Line

2 is diversified. The niche width of Tram Line 2 in the dimension of Operation Management is relatively high, which also shows that the demand provided by the ecological factor resources of Operation Management for Tram Line 2 presents diversified characteristics. For ecological factor resources with relatively high niche dimensions, the potential for survival and competition is relatively large. The niche width of Tram Line 2 in the dimension of Vehicle Environment and Cultural Image is relatively low, which shows that the utilization ability of ecological factor resources of Vehicle Environment and Cultural Image is highly specialized. Among them, in terms of Vehicle Environment, Tram Line 2 strictly implements ISO3381, TB/T1804-2009, and other standards, and the respondents' needs for the internal environment of vehicles tend to be consistent, and there is not much difference. In terms of Cultural Image, Tram Line 2 fully displays Chengdu elements such as Qingcheng Mountain, Wuhou Temple, Giant Panda, and Jinsha Site and has become a flowing Chengdu business card. Most of the respondents had lived in Chengdu for a long time and had high recognition of regional cultural elements.

There is little difference in the capacity to occupy niche resources and comprehensive competitiveness between Tram Line 2 and Bus Line 708. The comprehensive dimension niche width of Tram Line 2 is 2.214, while the comprehensive dimension niche width of Bus Line 708 is 2.127. Although the niche width of Tram Line 2 is relatively high, it does not show obvious advantages. Since its opening, Tram Line 2 has not been fully recognized by passengers. Many passengers said that compared with road buses, Tram Line 2 has no obvious advantages in time saving efficiency and passengers' feelings.

According to the above discussion, we can optimize Tram Line 2 according to the evaluation results. For example, the niche width of Tram Line 2 in City Size Matching and Regional Economic Matching are higher; we can carry out in-depth research on the behavior habits of residents along the route and adopt special strategies targeted, such as monthly service, firmly attracting residents along Tram Line 2 travel as the main means of transportation. We can also increase the infrastructure construction along Tram Line 2 to improve the driving capacity of Tram Line 2 to the surrounding economy and land value. For this point, the transformation project of Tram Line 2 has been put into practice. This also fully illustrates the feasibility of this study.

In the future, we will also establish the concept of tram niche overlap and tram niche suitability, and tram niche width, as an important tool of tram niche evaluation, to analyze the structure of the trams in the environmental space, study the competition between trams and other vehicles, and evaluate the tram ecological resource occupation or utilization ability and suitability to comprehensively evaluate the adaptability of trams to the ecological environment.

Data Availability

The data used to support the findings of this study are available from the corresponding authors upon request.

Conflicts of Interest

No competing interests exist concerning this study.

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References

[1] S. Yang, "Analysis of the ecological niche of transportation modes," *Modern Urban Studies*, vol. 25, no. 12, pp. 84–88, 2018.

[2] R. Wang, "Discussion of urban niche potential," *Urban environment and urban ecology*, vol. 1, no. 1, pp. 20–24, 1988.

[3] X. Han, "Connotation of urban niche and its r," *Modern Urban Studies*, vol. 8, no. 2, pp. 42-43, 2000.

[4] Y. Xiao and X. Mao, "Urban niche theory and its application," *Chinese Population Resources and Environment*, vol. 18, no. 5, pp. 41–45, 2018.

[5] D. Li, "Applied niche theory to analyze architectural phenomena," *World Architecture*, vol. 28, no. 4, pp. 132–134, 2007.

[6] X. Zhang and Y. Zou, "Study on niche evaluation of urban building ecology," *Architectural Journal*, vol. 55, no. 3, pp. 33–35, 2008.

[7] G. Li, "Analysis of urban building niche and strategy of–planning and design in Tokyo, Japan," *Urban Development Research*, vol. 19, no. 8, pp. 28–34, 2012.

[8] G. E. Hutchinson, "Concluding remarks," *Cold Spring Harbor Symposia on Quantitative Biology*, vol. 22, pp. 415–427, 1957.

[9] R. K. Ragade, K. W. Hipel, and T. E. Unny, "Nonquantitative methods in water resources management," *Jounal of Water Resources Planning and Management Division*, vol. 102, no. 2, pp. 297–309, 1976.

[10] R. W. Bosserman and R. K. Ragade, "Ecosystem analysis using fuzzy set theory," *Ecological Modelling*, vol. 16, no. 2-4, pp. 191–208, 1982.

[11] W. Wang, Z. Li, Y. Li, and F. Yang, "Fuzzy expression related to biotic community," *Ecological Modelling*, vol. 179, no. 3, pp. 367–372, 2004.

[12] G. Cao, "The definition of the niche by fuzzy set theory," *Ecological Modelling*, vol. 77, no. 1, pp. 65–71, 1995.

[13] F. Hao and Y. Li, "Initial exploration of the fuzzy niche," *Journal of Jiangsu University (Natural Science Edition)*, vol. 26, no. B12, pp. 91–94, 2005.

[14] D. Li, N. Pelvis, and X. Shi, "Affiliated cloud and subordinate cloud generators," *Computer Research and Development*, vol. 32, no. 6, pp. 15–20, 1995.

[15] Q. Di, D. Li, and D. R. Li, "Extension of cloud models and their application in spatial data mining," in *9th National Image Graphic Technology Conference*, pp. 521–526, Beijing, China, 1998.

[16] Z. Yang and D. Li, "Two-dimensional cloud model and its application in prediction," *Computer Science*, vol. 20, no. 11, pp. 961–969, 1998.

[17] D. Li, K. Di, and D. Li, "Explore association rules," *Software Journal*, vol. 11, no. 2, pp. 143–158, 2000.

[18] D. Li, "Uncertainty in knowledge representation," *Chinese engineering science*, vol. 2, no. 10, pp. 73–79, 2000.

[19] C. Liu, D. Li, and Y. Du, "Statistical analysis of the normal cloud model," *Information and control*, vol. 34, no. 2, pp. 236–239, 2005.

[20] C. Liu, M. Feng, and X. Dai, "A new reverse cloud algorithm based on cloud X information," *System Simulation Journal*, vol. 16, no. 11, pp. 2417–2420, 2004.

[21] H. Chen, B. Li, and C. Liu, "A nondeterministic inverse cloud algorithm," *Small computer systems*, vol. 36, no. 3, pp. 544–549, 2015.

[22] H. Chen and B. Li, "Uncertainty inference method based on cloud models," *Small microcomputer system*, vol. 32, no. 12, pp. 2449–2455, 2011.

[23] Y. Zhang, D. Zhao, and D. Li, "Similar clouds and their metric analysis methods," *Information and Control*, vol. 33, no. 2, pp. 129–132, 2004.

[24] W. Song and J. Zhu, "A goal-reference-point decision-making method based on normal cloud model and its application in distribution network planning evaluation," *Information Sciences*, vol. 577, no. 1, pp. 883–898, 2021.

[25] F. Liu and Y. Wang, "A novel method of risk assessment based on improved AHP-Cloud model for freezing pipe fracture," *Journal of Intelligent and Fuzzy Systems*, vol. 41, no. 1, pp. 1887–1900, 2021.

[26] H. Du and D. Li, "Cloud-based conceptual partitioning and its application to association mining," *Software Journal*, vol. 12, no. 2, pp. 196–203, 2001.

[27] Y. Chen, Y. Yang, and D. Du, "Study on performance evaluation of provincial ecological environment based on cloud model," *Soft Science*, vol. 32, no. 1, pp. 100–108, 2018.

[28] D. Li, J. Han, X. Shi, and M. Chung Chan, "Knowledge representation and discovery based on linguistic atoms," *Knowledge-Based Systems*, vol. 10, no. 7, pp. 431–440, 1998.

[29] D. Li, "Knowledge representation in KDD based on linguistic atoms," *Journal of Computer Science and Technology*, vol. 12, no. 6, pp. 481–496, 1997.

[30] D. Li and C. Liu, "On the universality of normal cloud models," *Chinese Engineering Science*, vol. 6, no. 8, pp. 28–34, 2004.

[31] V. Van, "Morphological variation and width of ecological niche," *American Naturalist*, vol. 99, no. 908, pp. 377–390, 1965.

[32] R. Macarthur and R. Levins, "The limiting similarity, convergence, and divergence of coexisting species," *American Naturalist*, vol. 101, no. 921, pp. 377–385, 1967.

[33] K. C. Colwell and D. J. Futuyma, "On the measurement of niche breadth and overlap," *Ecology*, vol. 52, no. 4, pp. 567–576, 1971.

[34] J. Pu, Z. Liu, and Z. Wang, "Construction of tram passenger comfort model from eco-city perspective," *Ergonomics*, vol. 26, no. 5, pp. 29–35, 2020.