Problem Chosen	2021 ShuWei Cup Summary Sheet	Team Control Number
C		202110286549

Summary

This paper mainly studies the personnel control of scenic spots and the rating of scenic spots in the epidemic environment. By querying data, looking for appropriate in index, this paper establishes the Analytic Hierarchy Process(AHP) model and Topsis model, uses the multi-objective optimization to establish quantitative model, and simulates and analyzes the results.

Question 1: Selection of relevant variables. First of all, the data set of the thesis eliminates the missing values and untrue values, uses excel software to delete the useless values and classifies and summarizes them, and obtains several more reliable complete data sets. Then use Arcmap software to draw comparisons based on the rating of scenic spots, then use Matlab software to draw a scatter plot according to the maximum reception volume of the scenic spot. Then draw a bar graph according to the distribution characteristics of the reception volume of each scenic spot. Finally, a scatter plot is drawn based on the number of tourists received throughout the year before and after the epidemic in a certain city, and fit a smooth curve for comparative analysis.

Question 2: This problem requires the establishment of an appropriate mathematical model through the collected scenery and consumption level of scenic spots, so as to make a reasonable quantitative evaluation and classification of them; To solve this problem, because there is no data support in the title and there are too many factors to evaluate the impact indicators of the scenic spots, we consider using the Analytic Hierarchy Process(AHP) to make decisions on the scenic spots.

Question 3: This problem requires the establishment of appropriate mathematical models according to different epidemic levels and other indicators that will lead to epidemic spread, so as to provide a reasonable flow limiting model for the scenic spot. To solve this problem, a load evaluation model is established, using the weighted Topsis model.

Question 4: In response to question four, we established the multi-objective model, the objective function of which is the income of the scenic spot and the experience of tourists. Relevant optimization of the scenic population control model obtained in the third question, establishes the corresponding objective function and constraint conditions. Use the analytic hierarchy process to determine the weights for analysis of the relevant influencing factors. For the multi-objective model, the optimal function is constructed to solve the problem, and the number limit rate of the scenic spot is 0.689. Finally, the number of people using the optimized model and the number of people who are not optimized are regressed, and the optimal number limit rate range is obtained by comparative analysis.

Question 5: In response to question five, by consulting a large amount of literature, from the time dimension, eight corresponding countermeasures are proposed for the short-term and long-term. Use the analytic hierarchy process for the eight response measures, set the weights, and judge the importance and urgency of the eight measures. Then according to the result sorting, draw the corresponding four-quadrant graph.

Key word: *Distribution characteristics; AHP; Topsis; Multi-objective model; Tourism*

Content

1. Introduction

1.1 Background

The new crown pneumonia epidemic that broke out in early 2020 has spread rapidly across the world. The rapid spread of this epidemic, the wide range of infections, and the difficulty of prevention and control have had a profound impact on the global economy, social development, and people’s lives, especially for the main personnel. The tourism industry characterized by mobility and agglomeration has caused a huge impact, and many hotels, restaurants, travel agencies, and scenic spots across the country have been forced to close down[1].

At present, the country is taking the initiative to change the decline in tourism development caused by the epidemic. Regarding the current situation under my country's national conditions, how to continue to develop the tourism industry is an urgent issue.Making a scientific tourism development plan based on the analysis of existing data is what we need to solve now.

1.2 Work

The current new crown pandemic has greatly affected the development of tourism. In the face of this downturn, we first need to know which scenic spots in the provinces of the country have been affected by this bad trend.What is their current rating of scenic spots and the maximum daily reception volume?We need to intuitively see the distribution characteristics of each scenic spot.For example, from the perspective of scenic spots rating, observe the number of scenic spots in each province under different ratings, the specific number of scenic spots owned by each province, etc.

2. Problem analysis

2.1 Data analysis

An attachment is provided for this question. The data in the attachment gives relevant information about Beijing 5A scenic spot. We found some relatively specific data from the Internet.

For many scenic spots data information, these data are missing and untrue. We cleaned these data and used the tool EXCEL to preprocess the scenic spot information as follows:

1. Delete the rows with missing data and modify the unreal data items.

2. We will classify and process the scenic spot data we found based on the attached data according to the scenic spot rating, province, city and region.Calculate the number of scenic spots in each province under different ratings, so that we can import them into Arcmap software later.

3. Calculate the maximum reception capacity based on the scenic area data we found based on the attached data and the maximum reception capacity is 75% of the maximum carrying capacity.Then delete other unnecessary items, only keep the latitude and longitude and the maximum reception volume, so that we can import it into the Matlab software later.

4. Calculate the median, mean and standard deviation of the maximum reception volume of the scenic spots in each province based on the data of the scenic spots we found based on the attached data and the maximum reception volume data.To facilitate our subsequent drawing.

5. Classify the whole year data of scenic spots in a specific city that we have found for several years by year and month.Use the above data to solve the problem by drawing.

2.2 Analysis of question one

Question 1 according to the data of scenic spots in various provinces we have collected, we are in order to show the distribution characteristics of these scenic spots more intuitively.We will make a more intuitive display from two dimensions, namely, the current ratings of scenic spots in various provinces and the maximum daily reception volume.These latitudes can intuitively show which provinces have developed tourism and compare the economic strength of each province.And predict the future development of each province.It can also be compared to the downturn in the tourism industry under the epidemic.

2.3 Analysis of question two

Question 2 requires the establishment of a suitable mathematical model for the collected scenic spots and consumption levels, so that they can be reasonably quantitatively evaluated and classified. In response to this problem, since there is no data support in the title and there are too many factors affecting the evaluation of scenic spots, we consider using the analytic hierarchy process to make decisions on scenic spots. By checking information online and consulting related experts, we selected five selection factors: scenery, cost, accommodation, food, and transportation. Taking into account the diversity of the selected samples, we selected three scenic spots: the Forbidden City, Shanghai Science and Technology Museum and Dazu Stone View Sculpture Museum as the alternative program.

2.4 Analysis of question three

Question 3 requires the establishment of appropriate mathematical models based on different epidemic levels and other indicators that will lead to the spread of the epidemic, and provide a reasonable current limit model for scenic spots. In response to this problem, a load evaluation model was first established, using a weighted topsis model, and the index was calculated by looking up information online and consulting relevant experts to locate the weight of existing patients in the province at 0.5, and the weight of vaccine popularity in the province was set at 0.3, and the daily average load The load is set at 0.2, and the calculation results of Gongwangfu Scenic Area, Panshan Scenic Area, and Taishan Scenic Area are calculated and normalized[2]. The result is multiplied by the daily average load to obtain the maximum number of people in the scenic area under the guarantee of safety.

2.5 Analysis of question four

Question 4 is to further optimize the number of tourist attractions under the comprehensive consideration of the revenue of the scenic spot and the tourist experience (using tourist scores as a quantification).Our goal is to provide the highest possible tourist scores when the income of the scenic spot is as high as possible, that is, the tourist experience is as good as possible.User experience is not only related to the number of tourists, but also related to several influencing factors in question 1. We can get the functional relationship between the user experience and the above factors by regression analysis, and then we can build an optimization model and solve it.Based on the data set we have collected, we look for the best number of tourists and find a reasonable number range.After the plan is drawn, the optimized and non-optimized comparison can be used to judge the effect of the number of scenic spots. After optimization, it can be concluded that the number limit rate of the scenic spot is 0.698, and it is obtained by comprehensively considering the income of the scenic spot and the tourist experience.

2.6 Analysis of question five

Question 5 requires us to provide government management departments with differentiated management plans for different scenic spots during the epidemic. By consulting a large number of documents and materials, we plan according to time, starting from the short-term to the mid-to long-term, and provide corresponding countermeasures for the restart of tourist attractions.

3. Symbol and Assumptions

3.1 Symbol Description

Table 3-1. Variable symbols and description

Variable symbol	Variable explanation
M	Target level, the best tourist spot
C	Standard level, representing different indicators
P	Target layer, representing different goals
$\lambda_{\max}$	Judgment matrix maximum eigenvalue
CI	Consistency index
CR	Concordance ratio
ω_i	The weight vector of each element in the judgment matrix
X	Normalization matrix
Z	Normalization matrix
D_i^+	Maximum distance
D_i^-	Minimum distance
S_i	Scores of different scenic spots

3.2 Fundamental assumptions

➢ Assuming that there is no time limit for the scenic data we collect, it only represents the data for the period after the epidemic.

➢ Assume that the daily maximum reception capacity of scenic spots in each province is 75% of the maximum carrying capacity.

4. Question 1: Basic data analysis of scenic spots in all provinces

4.1 Current ratings of scenic spots in each province

For the current rating of the scenic spot, we model the data with 3A, 4A, 5A and no distinction.We import data from excel tables, use Arcmap software for modeling, and draw abstract data into concrete maps of China.And according to the number of different ratings of scenic spots in each province, it is displayed in different colors to analyze the data more intuitively.The results are as follows:

In the 3A rated scenic spots, we use 5 different colors to indicate the number of scenic spots in each province.The specific number distribution of scenic spots is shown in Figure 4-1:

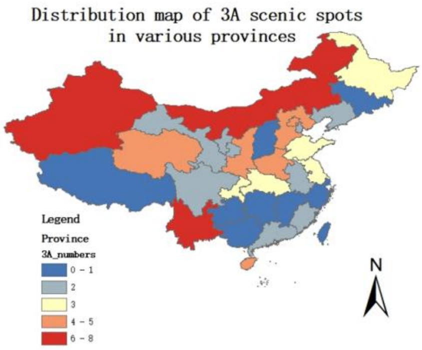

Figure 4-1. 3A Scenic spots.

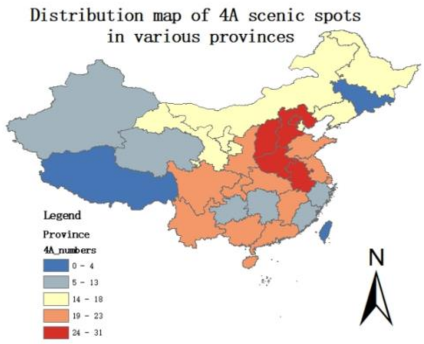

Figure 4-2. 4A Scenic spots.

From Figure 4-1, we can see that Xinjiang, Inner Mongolia and Yunnan have the largest number of 3A scenic spots.The least number is Tibet, Jilin, Taiwan and so on.

Among the scenic spots rated 4A and 5A, the specific number distribution of scenic spots is shown in Figure 4-2 and Figure 4-3:

From Figure 4-2, we can see that the largest number of 4A scenic spots are in Beijing, Tianjin, Shanxi and other regions.The least number is still in Tibet.From Figure 4-3, it can be seen that Jiangsu has the largest number of 5A scenic spots.The least is Taiwan and other places.

Looking at all the scenic spots in all provinces across the country, as shown in Figure 4-4.The most scenic spots are in Beijing, Tianjin, Jiangsu, Anhui and other places, and at least there are still Tibet and Taiwan.

From the comparison of these GIS maps, there are still many more developed scenic spots in the capital and Suzhou-Hangzhou area.The economy in this area is booming because of tourism, and the lush ports may be a major advantage of coastal cities.On the other hand, in the border areas of the country, especially in remote areas, it is very difficult to develop tourism in the harsh environment, and the local economy cannot be driven by fewer scenic spots.

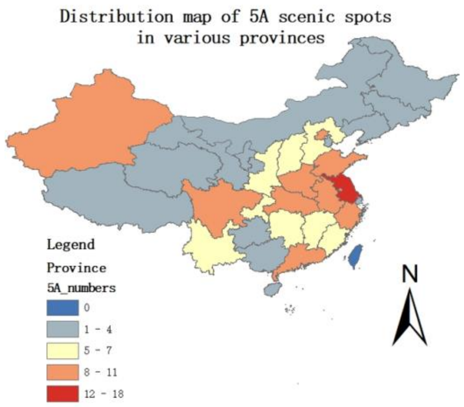

Figure 4-3. 5A Scenic spots.

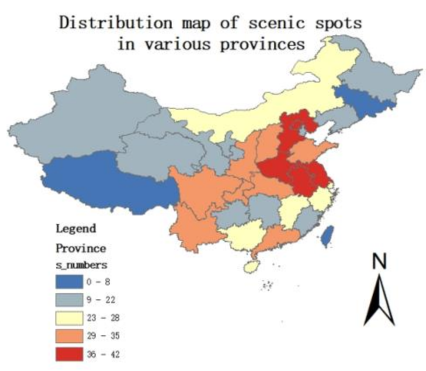

Figure 4-4. Scenic spots.

4.2 Reception volume of scenic spots in each province

For the maximum daily reception volume of scenic spots, we model the longitude and latitude of all scenic spots and the maximum daily number of visitors.The maximum daily reception capacity is 75% of the maximum carrying capacity.We import data from the pre-processed excel table and model it through matlab software,the abstract data is drawn into a scatter diagram describing the number of tourists in each scenic spot,.so as to help us further analyze the scenic data.The results are as follows:

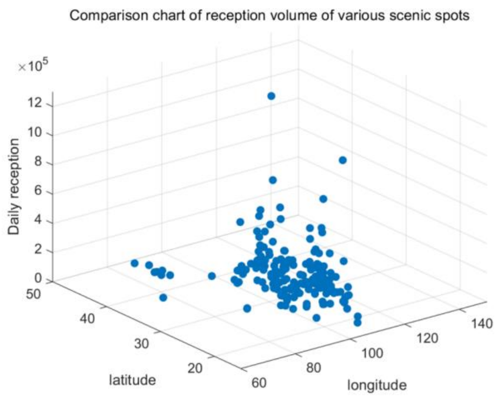

Figure 4-5. Comparison chart of reception volume of various scenic spots.

The specific reception volume distribution of scenic spots is shown in Figure 4-5:From Figure 4-5, we can see that the most visited scenic spots are Xi’an in Shaanxi and Guangzhou in Guangdong.The denser scenic spots are Henan, Anhui and Beijing.Tourists are relatively rare in Xinjiang and Hainan.It can be seen from this that not only the rating dimension, but also the daily reception dimension is also applicable to economically developed coastal cities.The number of tourists in border areas across the country is relatively small.

4.3 The distribution characteristics of the reception volume of each scenic

For the maximum daily reception volume of the scenic spot, we conduct comparative modeling from the median, mean and standard deviation.We import data from the pre-processed excel table, use matlab software for modeling, and draw the abstract distribution feature data into bar graphs.So that we can further intuitively analyze the scenic data.We selected North China for specific analysis, and the results are as follows:

The comparison chart of the median and the mean value of the reception volume of scenic spots in North China is shown in Figure 4-6:

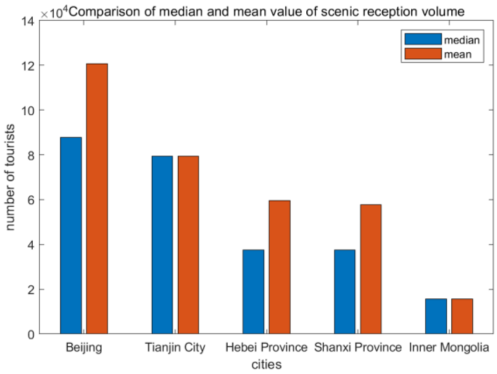

Figure 4-6. Median and mean.

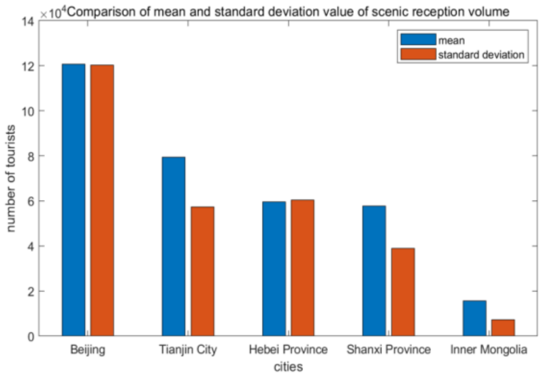

Figure 4-7. Mean and standard deviation.

The median and mean value can reflect the central tendency of the data distribution, and they can reflect the degree to which each data is close to its central value or clustered. We say that the median of a data is a good display of the characteristics of the data, and the mean of the data sometimes fluctuates because of the free boundary value. For Figure 4-6, we can see that the average tourist reception of Beijing scenic spots is much higher than the median. We can infer that some scenic spots are particularly popular with tourists.

The comparison chart of the mean and standard deviation of the reception volume of scenic spots in North China is shown in Figure 4-7:

The standard deviation of the data can reflect the degree of dispersion of the data distribution, and reflect the trend of each data away from its central value. The standard deviation is a measure of a set of data, and a smaller standard deviation means that the data is close to the average.For Figures 4-7, we can see that Shanxi and Inner Mongolia have relatively small standard deviations, which means that the reception volume and average value of each scenic spot are relatively small.

4.4 Tourist reception before and after the epidemic

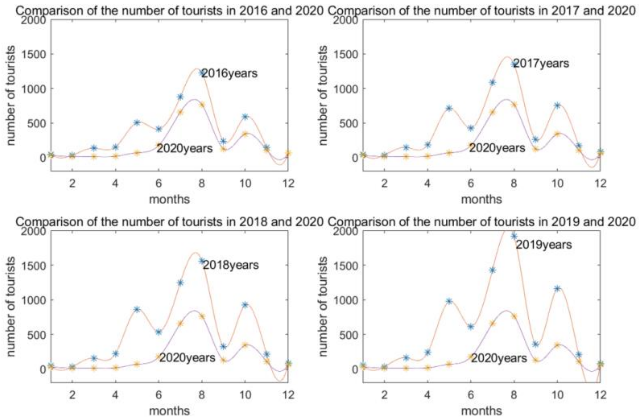

Figure 4-8. Comparison of tourist reception before and after the epidemic.

For the number of tourist receptions in a certain city's scenic spots in different years, we compared the monthly tourist receptions after the outbreak of the epidemic in 2020 with data from other years.We import data from the pre-processed excel table and model it through matlab software,Draw the specific data before and after the epidemic into a scatter plot, and fit the discrete points into a curve.This allows us to compare the scenic data over the years more intuitively.The results are as follows:

The specific tourist reception volume before and after the epidemic is shown in Figure 4-8:From Figure 4-8, we can understand that under the influence of the epidemic, the tourism industry has been sluggish throughout the year, and the monthly tourist reception has decreased dramatically.Especially in the peak tourist seasons of June, July, and August, from 2016 to 2019, there will be a continuous increase, and there will be a substantial decrease in 2020.

5. Question 2: Scenic Evaluation Classification Model

5.1 Evaluation Model of Science Spots Based on AHP

5.1.1 Build a hierarchical model

When applying the analytic hierarchy process to solve a problem, the problem must first be organized and hierarchized to construct a hierarchical structural model. These levels can be divided into three levels, the top level is the target level (M): select scenic spots. The middle layer is the criterion layer (C): scenery, expenses, accommodation, food, transportation. The lowest level is the plan layer (P): The Palace Museum, Shanghai Science and Technology Museum, Dazu Rock Carvings Scenic Spot. The establishment of a hierarchical structure is shown in Figure 5-1.

5.1.2 Construct all the judgment matrices in each level

Compare and score the target tree one by one from top to bottom, and establish a pairwise comparison judgment and optimization matrix. The scoring criteria are shown in Table 5-1.

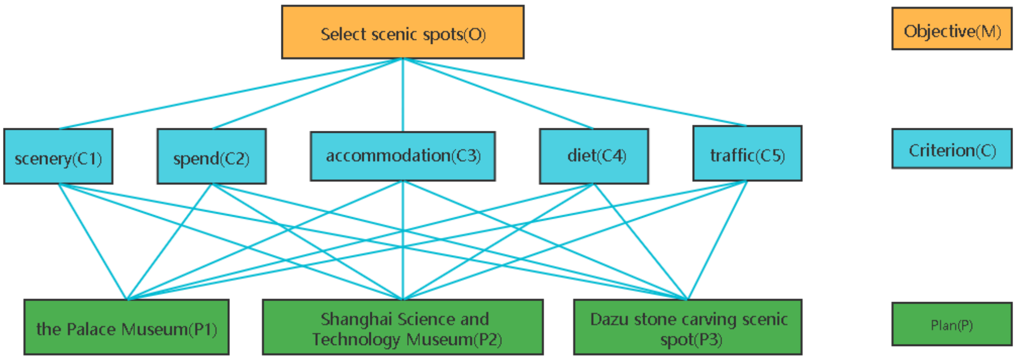

Figure 5-1. Hierarchical structure diagram of scenic spot evaluation.

Table 5-1. Scoring criteria for each level of the target tree

Scale	Importance	Illustrate
1	Equally important	The two factors are equally important
3	Slightly important	Comparing two factors, one is slightly more important than the other
5	Obviously important	Compared with the two factors, one is more important than the other
7	Strongly important	Two factors are more important than the other.
（2,4,6,8）	The median value	Use when you need a compromise

1. Construct a judgment matrix M-C, as shown in Table 5-2.
2. Construct the judgment matrix C-P, as shown in Table 5-3,5-4,5-5,5-6,5-7

Table 5-2. Judgment matrix M-C

M	C1	C2	C3	C4	C5
C1	1	1/2	4	3	3
C2	2	1	7	5	5
C3	1/4	1/7	1	1/2	1/3
C4	1/3	1/5	2	1	1
C5	1/3	1/5	3	1	1

Table 5-3. Judgment matrix C1-P

C1	P1	P2	P3
P1	1	2	4
P2	1/2	1	2
P3	1/4	1/2	1

Table 5-4. Judgment matrix C2-P

C2	P1	P2	P3
P1	1	1/3	1/8
P2	3	1	1/3
P3	8	3	1

Table 5-5. Judgment matrix C3-P

C3	P1	P2	P3
P1	1	1	4
P2	1	1	4
P3	1/4	1/4	1

Table 5-6. Judgment matrix C4-P

C4	P1	P2	P3
P1	1	2	5
P2	1/2	1	1
P3	1/5	1	1

Table 5-7. Judgment matrix C5-P

C5	P1	P2	P3
P1	1	2	1/4
P2	1/2	1	1/4
P3	4	4	1

5.1.3 Check the consistency of the judgment matrix

1. Calculate the consistency index CI.

$$CI = \lambda_{\max} - n / n - 1 \qquad (5\text{-}1)$$

2. Find the corresponding average random consistency index RI, as shown in Table 5-8.

Table 5-8. Average random consensus index

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

3. Calculate the consistency ratio CR

$$CR = CI / RI \qquad (5\text{-}2)$$

When CR<0.1, the consistency of the judgment matrix is considered acceptable, otherwise the corresponding judgment matrix is appropriately modified.

5.1.4 Calculate the weight

If the consistency of the judgment matrix A can be accepted, we can use the arithmetic average method, the geometric average method and the eigenvalue method to obtain the weights respectively, and then obtain the average weights.

5.2 Evaluation model solution

Using Matlab software, we first checked the consistency of the six judgment matrices, and Using Matlab software, we first checked the consistency of the six judgment matrices, and obtained the corresponding CR tables for large eigenvalues and consistency ratios as shown in Table 5-9.

Table 5-9. Consistency check

Matrix	M-C	C1-P	C2-P	C3-P	C4-P	C5-P
λ_{max}	5.0721	3.0000	3.0015	3.0000	3.0940	3.0536
CR	0.0161	0.0000	0.0015	0	0.0904	0.0516

Since the consistency ratios of all judgment matrices are less than 0.1, they all pass the consistency test. Three methods of arithmetic average method, geometric average method and eigenvalue method are used to obtain the weights respectively, and then the average weights are obtained. In previous papers, when using the analytic hierarchy process to solve problems, they all used one of the methods to calculate the weight, and different calculation methods may lead to deviations in the results. In order to ensure the robustness of the results, this paper uses three methods to obtain the weights respectively, and then calculates the scores of each scheme according to the obtained weight matrix, and performs ranking and comprehensive analysis, so as to avoid the deviation caused by using a single method. The conclusions drawn will be more comprehensive and effective, the weight analysis table is shown in Table 5-10.

Table 5-10. Weight analysis table

	Arithmetic Average	Geometric mean	Eigenvalue method	Average weight
Scenery	0.2623	0.2636	0.2636	0.2631
Spend	0.4744	0.4773	0.4758	0.4758
Accommodation	0.0545	0.0531	0.0538	0.0538
Diet	0.0985	0.0988	0.0981	0.0984
Traffic	0.1103	0.1072	0.1087	0.1087

According to the calculated average weight and the weight of each factor, the composite matrix table is shown in Table 5-11.

According to the above weight table, we can calculate the scores of three tourist attractions. For example, the scores of the Palace Museum are:

$0.5714 \times 0.2635+0.0820 \times 0.4755+0.4444 \times 0.0538+0.6098 \times 0.0981=0.2732$, Similarly, it can be calculated that the score of Shanghai Science and Technology

Museum is 0.2336 and that of Dazu stone carving scenic spot is 0.3840.

Table 5-11. Composite matrix

	Average weight	P1	P2	P3
Scenery	0.2635	0.5714	0.2857	0.1429
Spend	0.4755	0.0820	0.2364	0.6816
Accommodation	0.0538	0.4444	0.4444	0.1111
Diet	0.0981	0.6098	0.2247	0.1655
Traffic	0.1091	0.2081	0.1311	0.6608

6.Question 3: Tourist population load model of scenic

6.1 Load evaluation model of scenic spots based on Topsis

6.1.1 Introduction to TOPSIS Model

The Topsis method is a frequently used comprehensive evaluation method, which can make good use of the information of the original data, and the results can accurately reflect the gap between the various evaluation programs, the basic process of TOPSIS is to unify the original data matrix with the index type (general forward processing) to obtain the forward matrix, and then standardize the forward matrix, the purpose is to eliminate the influence of each index dimension, find the optimal scheme and the worst scheme, and then calculate the distance between the evaluation object and the optimal and worst schemes, the relative proximity between the evaluation object and the optimal scheme is obtained[3]. This method has no strict restrictions on the data distribution and sample size, and the data calculation is simple and easy.

6.1.2 Steps to build a Topsis model

1. Normalize the original data

1)Converting very small indicators to very large indicators, the formula is as follows:

$$\max - x \tag{6-1}$$

2) Intermediate indicators are transformed into very large indicators $\{x_i\}$ is a set of intermediate index sequences, and the best value is x_{best}, the formula for normalization is as follows:

$$M = \max\{|x_i - x_{best}|\}, \quad \tilde{x}_i = 1 - |x_i - x_{best}| / M \tag{6-2}$$

3) Interval indicators are transformed into very large indicators $\{x_i\}$ Is a set of intermediate index sequences, and the best interval is $[a,b]$, then the formula for normalization is as follows:

$$M=\max\left\{a-\min\left\{x_i\right\},\max\left\{x_i\right\}-b\right\},x_i=\begin{cases}1-(a-x)/M,x<a\\1,a\le x\le b\\1-(x-b)/M,x>b\end{cases}\qquad(6\text{-}3)$$

2. Normalization matrix normalization

The purpose of standardization is to eliminate the influence of different dimensions. Assuming that there are n objects to be rated and m evaluation indicators (which have been positive), the positive matrix is as follows:

$$X=\begin{bmatrix}x_{11}&x_{12}&\cdots&x_{1m}\\x_{21}&x_{22}&\cdots&x_{2m}\\\vdots&\vdots&\ddots&\vdots\\x_{n1}&x_{n2}&\cdots&x_{nm}\end{bmatrix}$$

Then the normalized matrix is denoted as Z, and each element in Z:

$$z_{ij}=x_{ij}/\sqrt{\sum_{i=1}^{n}x_{ij}^{\ 2}}\qquad(6\text{-}4)$$

3. Calculate the score and normalize

Suppose there are n objects to be evaluated and a standardized matrix of m evaluation indicators:

$$Z=\begin{bmatrix}z_{11}&z_{12}&\cdots&z_{1m}\\z_{21}&z_{22}&\cdots&z_{2m}\\\vdots&\vdots&\ddots&\vdots\\z_{n1}&z_{n2}&\cdots&z_{nm}\end{bmatrix}$$

Define maximum: $Z^{+}=\left(Z_1^{\ +},Z_2^{\ +},\cdots,Z_m^{\ +}\right)$

$=\left(\max\left\{z_{11},z_{21},\cdots,z_{n1}\right\},\max\left\{z_{12},z_{22},\cdots,z_{n2}\right\},\cdots,\max\left\{z_{1m},z_{2m},\cdots,z_{nm}\right\}\right)$

Define minimum: $Z^{-}=\left(Z_1^{\ -},Z_2^{\ -},\cdots,Z_m^{\ -}\right)$

$=\left(\min\left\{z_{11},z_{21},\cdots,z_{n1}\right\},\min\left\{z_{12},z_{22},\cdots,z_{n2}\right\},\cdots,\min\left\{z_{1m},z_{2m},\cdots,z_{nm}\right\}\right)$

Define the distance between the evaluation object and the $i\left(i=1,2,\cdots,n\right)$

maximum value $D_i^{+}=\sqrt{\sum_{j=1}^{m}\omega_{\mathrm{j}}\left(Z_j^{\ -}-z_{ij}\right)^2}$

Define the distance between the evaluation object and the $i\left(i=1,2,\cdots,n\right)$

minimum value $D_i^{-}=\sqrt{\sum_{j=1}^{m}\omega_{\mathrm{j}}\left(Z_j^{\ -}-z_{ij}\right)^2}$ well, we can calculate $i\left(i=1,2,\cdots,n\right)$

non normalized score of evaluation object： $S_i=D_i^-/(D_i^-+D_i^+)$,Obviously ,$0\le S_i\le 1$，And the larger S_i, the larger D_i^{+}, that is, the closer to the maximum value.

6.2 Establishment of load evaluation model

According to the previous problem analysis, table 6-1 is established.Using Matlab software, calculate the data in Table 6-1 to get the maximum distance, minimum distance and score corresponding to each value. As shown in Table 6-2.

Table 6-1. Topsis matrix

Scenic spot	Existing patients in the province (person)	Vaccine popularity in province (%)	Carrying capacity (10000 persons)
Prince Gong mansion scenic spot	46	96.7%	4
Panshan scenic	16	81.7%	5.2
The Taishan Scenic	31	82.2	11.4
Indicator type	Very small index	Very large index	Very small index

Table 6-2. Ranking table

Scenic spot	D_i^+	D_i^-	Non normalized score	Normalized score	Ranking
Prince Gong mansion scenic spot	1.9999	0.3472	0.1479	0.1332	3
Panshan scenic	0.5472	0.6946	0.5593	0.5039	1
The Taishan Scenic	0.4693	0.3162	0.4025	0.3629	2

Visualize the data in Table 6-2 to get Figure 6-1.

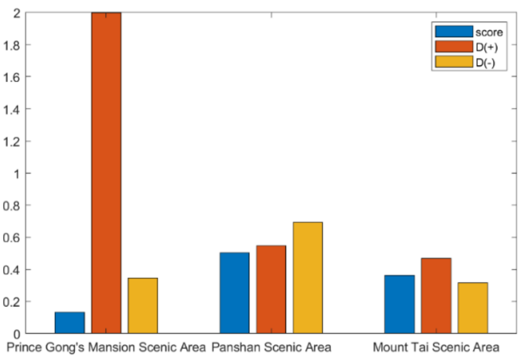

Figure 6-1. Visualize the results.

From Figure 6-1, the final score of each scenic spot can be obtained intuitively. The higher the score, the safer the scenic spot. You can multiply the daily load by the final normalized score to get the maximum number of people in each scenic spot. Take Panshan Scenic Area as an example, this scenic area carries the most0.5039× 5.2=2.62028 million person-times.

7. Question 4: The Optimization Model of Limiting Population Size in Scenic

7.1 Establishment the model for determining the number of tourists

7.1.1Multi-objective optimization model establishment Objective function

Before the optimization model is established, we first clarify the objective function[4].The determination of the objective function of this problem can be transformed into the optimal solution of the game. That is, the number of tourists judgment model we need to solve should ensure that the tourist income is high while the tourist experience is as good as possible.

Suppose the expression of the number of people in the scenic spot is $f(N)$, and the expression of the tourist experience is $f(E)$.

The goal is:

$$\max: f(N) \quad \max: f(E) \tag{7-1}$$

According to our analysis, we establish a comprehensive tourist number judgment model based on the above two goals, with two influencing factors: scenic spots and scenic spots, scenic spots and tourists. The scenic spot and epidemic level set a threshold for the scenic spot score. When it is lower than 4, the impact on the number of scenic spots is to reduce the number of people and increase the flow limit ratio. Suppose the influence function of scenic spot income is x_1, the influence function of scenic spot score is x_2, and their corresponding weight is β_1, β_2. That is the comprehensive influence factor of the relationship between the number of people in the scenic spot and the task on the pricing is:

$$f_1 = \beta_1 \cdot x_1 + \beta_2 \cdot x_2 \tag{7-2}$$

There is only one outlier degree for the influencing factors of scenic spots and scenic spots. Suppose the influencing factor of this factor is a coefficient f_2 and the outlier degree function is y , then:

$$f_2 = y \tag{7-3}$$

The coefficient of the influencing factor of scenic spots and tourists is α_1, the coefficient of influencing factors of scenic spots and scenic spots is α_2, the number of people in the i scenic spot is N_i, the total number of tasks is n, and the comprehensive model of the number of people is $f(N)$ as follows:

$$f(N) = \frac{1}{n}\sum_1^n N_i / \left(\alpha_1 \cdot f_1 + \alpha_2 \cdot f_2\right) \tag{7-4}$$

The score of a scenic spot is determined by the number of scenic spots, the influencing factors of scenic spots and scenic spots, and the influencing factors of scenic spots and tourists. The three influencing factor functions are set as F_1、F_2、F_3.At the same time, the average user preference and the service attitude of the scenic spot have a certain impact on the ratings of tourists. We simplify these two influencing factors into two coefficients α and β .The comprehensive model of task execution rate is f(E) as follows:

$$f(E)=\alpha\cdot\beta\cdot\left(F_1+F_2+F_3\right) \tag{7-5}$$

Among them, the average score is also the case. Suppose these two factors are α and β .The total number of scenic spots is n , and the score of the i-th scenic spot is E_i , then the objective function with the best average execution rate is:

$$\begin{gathered}\max\ f(E)=\alpha\cdot\beta\cdot\frac{\sum_1^n E_i}{n}\\ \min\ f(N)=\sum_1^n N_i\end{gathered} \tag{7-6}$$

Independent variable range

When considering the range of independent variables, we need to clarify the number of independent variables and the relationship with the dependent variables. We draw its logical block diagram as follows,Figure 7-1. Logical relationship structure of independent variable and dependent variable.We explain the logical structure as follows:

- The number of people is determined by two factors: the relationship between scenic spots and scenic spots, and the relationship between scenic spots and tourists;
- The relationship between the scenic spot and the scenic spot is described by the outlier degree of the scenic spot, that is, the LOF outlier factor;
- The relationship between a scenic spot and tourists is characterized by two factors: the restriction on the number of tourists in the scenic spot, and the maximum carrying capacity of the scenic spot for tourists:
- The score is affected by three factors: the number of people, the relationship between scenic spots and scenic spots, and the relationship between scenic spots and tourists.Among them, the number of people has a game relationship with them. A decline in the number of people leads to an increase in the score; an increase in the number of people leads to a decline in the score.

  First of all, we can determine the average preference of users and the service attitude of scenic spots based on experience to score the scores of tourists as shown in the following table (the score is set according to the Likert five-level scale method):

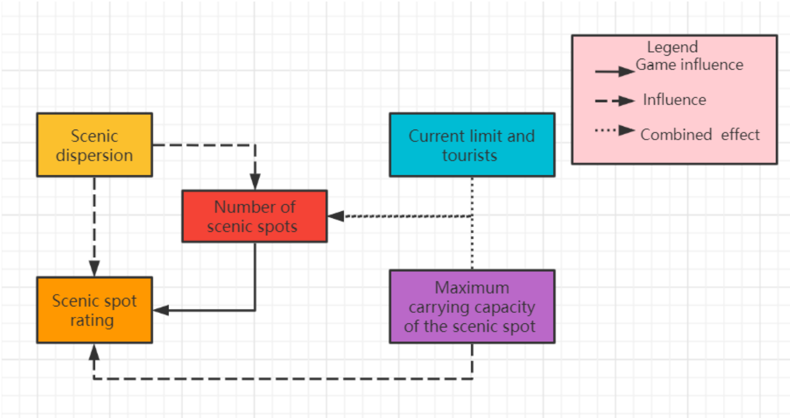

Figure 7-1. Logical relationship structure of independent variable and dependent variable.

Table 7-1. α、β Value comparison table

Tourist preferences	α	Scenic service attitude	β
Five	0.99	Five	0.99
Four	0.97	Four	0.97
Three	0.94	Three	0.95
Two	0.90	Two	0.93
One	0.80	One	0.91

Restrictions

In order to achieve the optimal goal, the following constraints are imposed on the number of people N and score E before optimization[5]:

$$\begin{cases} f(N) \le N \\ f(E) \ge E \end{cases} \tag{7-7}$$

Multi-objective optimization model

The number optimization is to optimize the number of people set in the scenic spot when the scenic spot has a certain score. The score optimization refers to the optimization of the tourist score when the number of people in the scenic spot is certain. In order to optimize the objective function, the optimization model we give is as follows:

$$\max f(E)=\frac{\sum_1^n E_i}{n} \quad \min f(N)=\sum_1^n N_i$$

$$\text{s.t.}\begin{cases}\left(\sum_1^{\text{n}} E_i\cdot\alpha_i\cdot\beta_i\right)/n\ge N\\ \sum_1^n E_i\le N\\ 0\le N_i\le N_{S_i}\\ i=1\ldots n\end{cases} \tag{7-8}$$

$$\text{s.t.}\begin{cases}\left(\sum_1^{\text{n}} E_i\cdot\alpha_i\cdot\beta_i\right)/n\ge N\\ \sum_1^n E_i\le N\\ 0\le N_i\le N_{S_i}\\ i=1\ldots n\end{cases} \tag{7-9}$$

Among them, E_i is the score of the i-th scenic spot after optimization, N_i is set for the number of people in the i-th scenic spot after optimization, and N_{S_i} is the largest carrying capacity of the scenic spot.

We introduce the maximum expected income I , and suppose the average price of a certain scenic spot is P_i, and the number of people in a certain scenic spot is N_i, then the maximum expected income of the scenic spot can be approximated by the following formula:

$$\max I=\sum_1^n P_i\cdot N_i \tag{7-10}$$

7.1.2Optimization model solving

Analytic hierarchy process to determine weight

In order to determine the two influencing factors of scenic spots and tourists, the scenic restrictions on the number of tourists, and the weight of the scenic maximum carrying capacity for tourists is β_1 and β_2 .We searched for relevant documents and used the analytic hierarchy process based on the literature and experience to finally determine the value: 0.6892 , 0.3108.

Regression fitting function

Using the existing data to regress the pricing, the optimized number of people is estimated, and the unoptimized number of people is $f\left(N_F\right)$ predicted to get the regression results.

The noise removal is 0.7780 and 0.8523 respectively. In order to better show the reasonable number of people, we draw the distribution of two curved surface pricing functions in the same three-dimensional coordinate system, as shown above.Here is an explanation of the reasonable number of people range: the reasonable number of people range is the space interval between the optimized number of people estimate and the non-optimized number of people estimate curved surface.

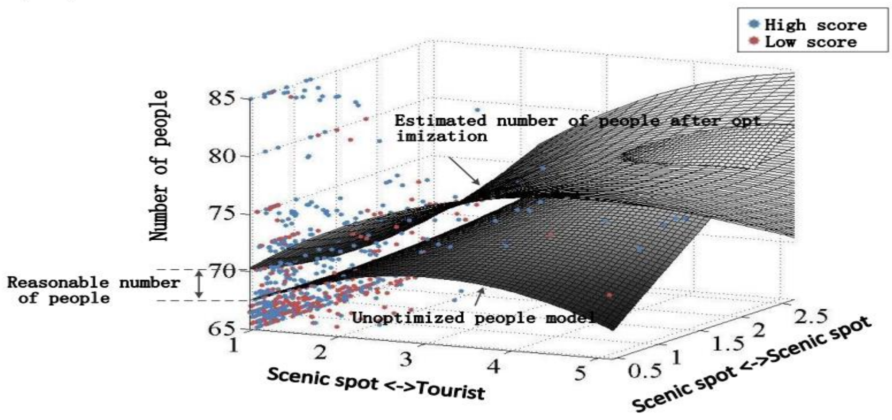

Figure 7-2. Optimized/unoptimized surface and reasonable number of people.

7.2 Optimize and compare the number of people in the question

For the data given in the question, we calculated that the revenue of the scenic spot was 57896.4, and the population restriction rate was 62.8%. That is, we optimize the number of people in the question.Since the algorithm needs to traverse to search for the optimal solution, searching for the global optimal solution is time-consuming, we use genetic algorithm to find the local optimal solution to approximate the global optimal solution, and each takes 50 sets of data points for curve fitting, and selects 50 scenic spots with income between 55000 and 63000, and the optimization results are displayed on the image at the same time. We optimize with the goal of maximizing the income of the scenic spot to get the fitting curve 1 of the figure below, and optimize with the highest score as the goal to get the figure below Fitting curve 2.

In the figure, we have marked a data point, as shown at the "X" in the figure, and the coordinates are (59896.5, 0.628). By constructing a model, we can clearly know that the restriction rate of the scenic spot can be set at 0.698. At this time, the income of the scenic spot is the largest, and at the same time, the tourist score is the highest, that is, the tourist experience is the best.

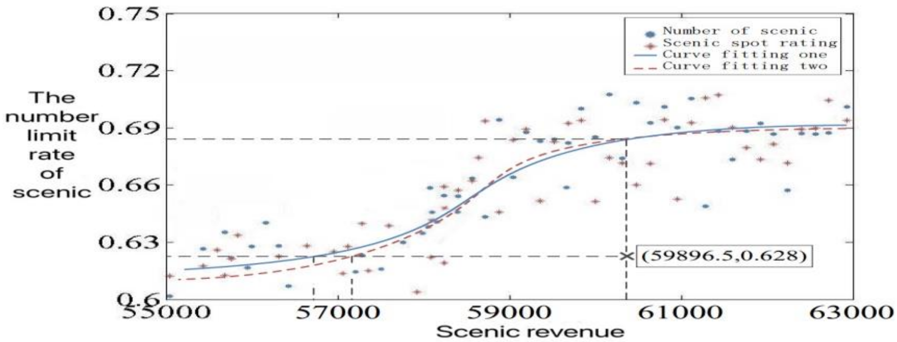

Figure 7-3. Results display and comparison.

8.Question 5: Propose countermeasures

8.1 Countermeasures for the recent restart of tourist attractions

Short-term measures 1

Part of the local government related financial assistance. For scenic spots in poor areas, relevant financial assistance, government help publicity.Targeted subsidies for cultural monuments in various places, such as tax reductions and exemptions, lower rents, etc., in order to maintain normal business. Advocate leading enterprises to help small scenic spots and stimulate domestic demand in order to achieve the sustainable and healthy development of the tourism industry.

Short-term measures 2

Advocate local travel and stimulate domestic demand. Compared with foreign tourists, local tourists have a higher stickiness coefficient and a higher return visit rate.The local government appropriately advocates local people to travel locally, which is not only conducive to epidemic prevention and control, but also conducive to promoting the healthy development of the local tourism industry.For example, scenic spots with a large tourist carrying capacity are encouraged to issue free tickets for some local scenic spots, and the government encourages relevant enterprises to conduct local tours during the establishment of groups.

Short-term measures 3

In response to the level of the epidemic, corresponding measures have been taken.The current epidemic prevention and control rate has been regularized, and it is necessary for scenic spots to formulate corresponding corresponding measures[6].According to the fourth question, the optimal number of people in scenic spots is limited to 0.68. For scenic spots in medium and high-risk areas, tourists are restricted from going out. Low-risk areas can control the number of people to the maximum carrying capacity of the scenic spot*0.68, which is the basis for balancing scenic revenue and tourist experience To set it on.

Short-term measures 4

Promote various aspects according to the level of the scenic spot. The government formulates corresponding promotion strategies for different scenic spots.For example, 5A and 4A-level scenic spots are relatively well-known and familiar to tourists, and can be promoted in appropriate market segments to achieve refined promotion. For 3A and below scenic spots, tourists are relatively unfamiliar, so they can increase their publicity and promote them accordingly.

8.2 Countermeasures for the revitalization of tourist attractions

Long-term measures 1:

Improve the digital infrastructure of scenic spots. Digitalization of scenic spots has become a trend.From the market perspective, online ticket reservations[7], real-name reservations for scenic spots, and unmanned ticket machines for scenic spots have become a development direction for scenic spots in the current digital age.

Long-term measures 2:

Empower the scenic area culture and inherit Chinese culture. With the rapid development of the Internet, traditional culture is declining.The government should empower the cultural attractions and let the scenic spots start by promoting the local culture and digging into the deep connotation of the scenic spots, so as to enhance the core competitiveness of the scenic spots themselves.

Long-term measures 3:

Form an industrial chain structure. The government has stepped up support for the diversified development of the industrial chain of scenic spots, and construction of related entertainment facilities in scenic spots.Corresponding cultural entertainment projects can be built for natural scenery to improve the experience of tourists.

Long-term measures 4:

The government promoted at a high level, and the overall file was upgraded. Relying on the existing 5A and 4A-level scenic spots[8], through compound development, incubate super IP, build a good tourism brand, expand new tourism product formats, and strengthen the tourism economy. Promote the creation of A-level scenic spots and improve the overall development quality of the city's A-level scenic spots.

8.3 Measures to quantify

For the short-term and long-term time-only dimensions, corresponding countermeasures are proposed. A total of eight countermeasures have been proposed.Using the Analytic Hierarchy Process, the eight measures are scored correspondingly by consulting literature and empirical analysis, and the corresponding weights of the corresponding measures are obtained, and the judgment matrix is obtained as follows.

Table 8-1. Consistency test1

Judgment matrix	M-C	C1-P	C2-P	C3-P	C4-P
λ_{max}	4.073	3.111	3.216	3.024	3.083
CR	0.027	0.014	0.009	0.018	0.008

Table 8-2. Consistency test2

Judgment matrix	M-C	C11-P	C22-P	C33-P	C44-P
λ_{max}	4.033	3.014	3.023	3.003	3.086
CR	0.012	0.013	0.023	0.003	0.083

$CR = CI / RI$ When $CR < 0.1$, it is considered that the judgment matrix has passed the consistency test and all the judgment matrices have passed the consistency test.At the same time, calculate the weight of each measure, judge its importance, and then put forward more specific countermeasures.

Table 8-3. Weight matrices1

Average weight	Short-term measures 1	Short-term measures 2	Short-term measures 3	Short-term measures 4
Importance	0.279	0.217	0.310	0.194

Table 8-4. Weight matrices2

Average weight	Long-term measures 1	Long-term measures 2	Long-term measures 3	Long-term measures 4
Importance	0.267	0.236	0.203	0.294

According to the weight of importance of the above measures, the above eight measures are classified and the following four-quadrant graph is drawn.

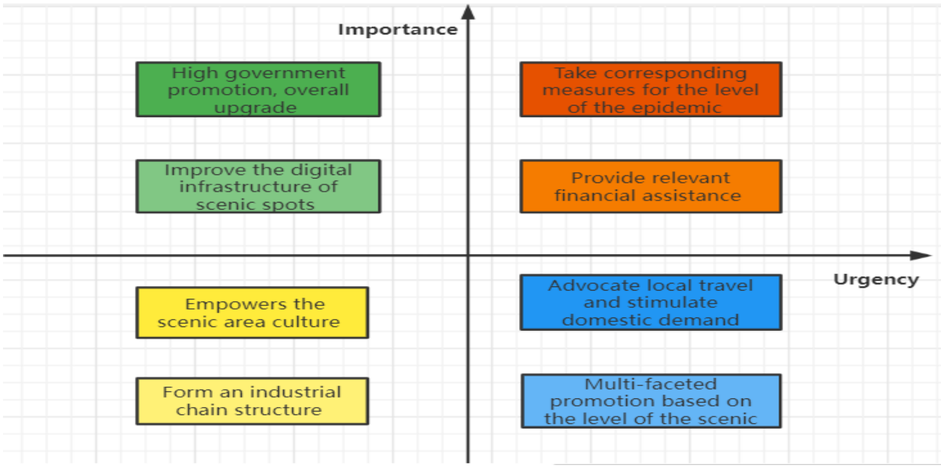

Figure 8-1. Four quadrant diagram.

9.Strengths and Weakness

9.1 Model advantages

One:In the use of analytic hierarchy process, three methods of arithmetic average method, geometric average method and eigenvalue method are used to obtain the weights respectively, and then the average weights are obtained. Avoiding the deviation caused by using a single method, the conclusions drawn will be more comprehensive and more effective.

Two:Regression analysis is performed between the optimized number limit model and the unoptimized number model, and through comparison, a reasonable number range of the scenic spot is obtained, which makes the result more intuitive.

Three:The model is relatively complete. This article starts from the study of a series of features to model establishment, model solution, and model verification. The overall framework is relatively complete.

9.2 Disadvantages of the model

For evaluation questions, the analytic hierarchy process is used, which is relatively subjective, and the scoring may be subjective.

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Appendix

##ExcelData preprocessing##

=COUNTIF(A2:A6) //Find the number of scenic spots in the same province
=SUM(A2:A32) //Sum
=A2*0.75
//Maximum reception capacity is 75% of maximum capacity

Matlab Software drawing

```
%Question one
###################### question one ##################################

%Comparison chart of reception volume of various scenic spots.

scatter3(X,Y,Z,'filled');      %3D scatter plot
xlabel('longitude ');ylabel('latitude');zlabel('Daily reception');
%Axis
title('Comparison chart of reception volume of various scenic spots');
%title
axis([60 150 15 50 0 1300000]);      %Axis range

%Distribution characteristics of reception volume of scenic spots in various provinces
%A median
%B Mean
%C standard deviation
%D max
%E minimum
%Median vs mean

x=1:0.5:3;
bar(x,A);
set(gca,'xtick',[1:0.5:3]);
set(gca,'xticklabel',A1);
xlabel('cities');
ylabel('number of tourists');
title('Comparison of median and mean value of scenic reception volume');
legend('median','mean');

%Mean vs standard deviation
bar(x,B);
set(gca,'xtick',[1:0.5:3]);
```

```
set(gca,'xticklabel',A1);
xlabel('cities');
ylabel('number of tourists');
title('Comparison of mean and standard deviation value of scenic reception volume');
legend('mean','standard deviation');

%Median vs maximum
bar(x,C);
set(gca,'xtick',[1:0.5:3]);
set(gca,'xticklabel',A1);
xlabel('cities');
ylabel('number of tourists');
title('Comparison of median and max value of scenic reception volume');
legend('median','max');

%Median vs minimum
bar(x,D);
set(gca,'xtick',[1:0.5:3]);
set(gca,'xticklabel',A1);
xlabel('cities');
ylabel('number of tourists');
title('Comparison of median and min value of scenic reception volume');
legend('median','min');

%Comparison of tourist reception before and after the epidemic .
months
y_2016
y_2017
y_2018
y_2019
y_2020
x=1:0.01:12;


%2016 vs 2020

subplot(2,2,1);

y=spline(months,y_2016,x); %Discrete points are fitted to a smooth curve
plot(months,y_2016,'*',x,y);
hold on    %Keep original image
y=spline(months,y_2020,x);
plot(months,y_2020,'*',x,y);
xlabel('months');
```

```
ylabel('number of tourists');
title('Comparison of the number of tourists in 2016 and 2020');
axis([1 12 -200 2000]);
text(7.98,1237,'2016years');%legend
text(5.9,145.8,'2020years');
hold off


%2017 vs 2020


subplot(2,2,2);

y=spline(months,y_2017,x);
plot(months,y_2017,'*',x,y);
hold on
y=spline(months,y_2020,x);
plot(months,y_2020,'*',x,y);
xlabel('months');
ylabel('number of tourists');
title('Comparison of the number of tourists in 2017 and 2020');
axis([1 12 -200 2000]);
text(7.95,1381,'2017years');
text(5.92,151,'2020years');
hold off


%2018 vs 2020


subplot(2,2,3);
xlabel('months');
y=spline(months,y_2018,x);
plot(months,y_2018,'*',x,y);
hold on
y=spline(months,y_2020,x);
plot(months,y_2020,'*',x,y);
xlabel('months');
ylabel('number of tourists');
title('Comparison of the number of tourists in 2018 and 2020');
axis([1 12 -200 2000]);
text(8.05,1515,'2018years');
text(6.02,180.4,'2020years');
hold off
```

```
%2019 vs 2020


subplot(2,2,4);

y=spline(months,y_2019,x);
plot(months,y_2019,'*',x,y);
hold on
y=spline(months,y_2020,x);
plot(months,y_2020,'*',x,y);
xlabel('months');
ylabel('number of tourists');
title('Comparison of the number of tourists in 2019 and 2020');
axis([1 12 -200 2000]);
text(8.09,1808,'2019years');
text(6,174,'2020years');
hold off

%Question two
###################### question two #################################

r=[1 2 3]
bar(r,ao1);
set(gca,'xtick',[1 2 3]);
set(gca,'xticklabel',ao);
legend('score','D(+)','D(-)');

%Question three
###################### question three ##################################

[n,m] = size(X);
disp(['共有' num2str(n) '个评价对象, ' num2str(m) '个评价指标'])
Judge = input(['这' num2str(m) '个指标是否需要正向化处理，需要1 ，不需0：   ']);
if Judge == 1
    Position = input('请输入需要正向化处理的指标所在的列');
    disp('输入处理的这些列的指标类型（1：极小型， 2：中间型， 3：区间型）
    ')
    Type = input('：     ');
    for i = 1 : size(Position,2)
    end
    disp('正向化后的矩阵 X =   ')
    disp(X)
```

```
end
Z = X ./ repmat(sum(X.*X) .^ 0.5, n, 1);
disp('标准化矩阵 Z = ')
disp(Z)
D_P = sum([(Z - repmat(max(Z),n,1)) .^ 2 ],2) .^ 0.5;     % D+ 与最大值的距离向
    量
D_N = sum([(Z - repmat(min(Z),n,1)) .^ 2 ],2) .^ 0.5;     % D- 与最小值的距离向量
S = D_N ./ (D_P+D_N);
disp('最后的得分为：')
stand_S = S / sum(S)
[sorted_S,index] = sort(stand_S ,'descend')


%Question four
###################### question four ##################################
clear all
%Number of visitors received per day
day_visitor = xlsread('data.xlsx','D2:D185');
%Maximum carrying capacity of the scenic spot
max_visitor = xlsread('data.xlsx','E2:E185');
%Ticket prices for scenic spots
price = xlsread('data.xlsx','F2:F185');
%Tourists score ticket prices
  score=xlsread('data.xlsx','H2:H185');
limitednum=max(max_visitor);
m_num=day_visitor*0.75;
  m_limited=limitednum./mean(limitednum);

%Weights
W=[0.6892,0.3108];
two_factor=W.*[m_limited;m_num];

% Optimize, the number of people returns
X=[ones(length(X_on(:,1)),1),X_on(:,1),X_on(:,1).^2,X_on(:,1).^3,...
X_on(:,2),X_on(:,2).^2,X_on(:,2).^3];
[b_on,~,~,~,stats_on]=regress(max_visitor(on),X);
plot3(X_on(:,1),X_on(:,2),price(on),'.')
hold on
ezsurf('65.9679+6.4501*x+-0.9066*x.^2+0.0340*x.^3+-2.8345*y+0.9785*y.^2+-0.1
616*y.^2',[min(X_on(:,1)),max(X_on(:,1))-3.5,min(X_on(:,2)),max(X_on(:,2))-1.2])
hold on

% No optimization, the number of people returns
X=[ones(length(X_off(:,1)),1),X_off(:,1),X_off(:,1).^2,...
```

```
X_off(:,2),X_off(:,2).^2,X_off(:,1).*X_off(:,2)];
[b_off,~,~,~,stats_off]=regress(price(off),X);
plot3(X_off(:,1),X_off(:,2),price(off),'.r')

hold on
ezsurf('64.8343+3.8219*x+-0.7506*x.^2+-2.1090*y+-0.1109*y.^2+1.6097*x.*y',[mi
n(X_off(:,1)),max(X_off(:,1))-3.5,min(X_off(:,2)),max(X_off(:,2))-1.2])
hold on

[D]=dis_matrix_O2P(day_visitor,max_visitor);
[num,limitednum]=amount(max_visitor,D,1000);

%Reasonable number of people
[visitor_top,visitor_bottom]=predict(day_visitor,max_visitor);
visitor_top=max(max_visitor);
visitor_bottom=min(max_visitor);
x0=70*ones(185,1);
y=fmincon(@fun1,x0,[],[],[],[],visitor_top,visitor_bottom)*0.01

%AHP
A =[1,1/3,1/5,1;3,1,1,5;5,1,1,5;1,1/5,1/5,1];
[n,~] = size(A);

%Find the eigenvector and eigenvalue and find the maximum eigenvalue and its
corresponding eigenvector
[V,D] = eig(A);
[max_lamada , index ] = max(sum(D));
w = abs(V(:,index));
w = w ./ sum(w);

%The following is the consistency check
CI = (max_lamada - n ) / ( n - 1 );
RI = [0 0 0.52 0.89 1.12 1.26 1.36 1.41 1.46 1.49 1.52 1.54 1.56 1.58 1.59 1.60 1.61
    1.615 1.62 1.63];
CR = CI / RI(n);
if CR<0.10
    disp('The consistency of this matrix is acceptable !');
    disp('CI=');disp(CI);
    disp('CR=');disp(CR);
    disp('Weight vector: ');
    disp(w);
    disp('Maximum characteristic root of criterion level: ');
    disp(max_lamada);
else
```

```
    disp('The consistency verification of this matrix failed, please re-score !');
end
```