The judges scoring, note	Team number： 10317	The judges scoring, note
The judges scoring, note	Problem： C	The judges scoring, note

Title：The Design of Family Summer Travelling Plan

Abstract

A cozy family trip is always the pursuit of our humans. We just want to get the most value and enjoyment under the same time and space conditions, especially in designing the travel packages.

Our report selects Chengdu as our travel city, at the meantime, selects 11 popular places of interest. According to different needs of family, we build3independent models,

Model 1, visiting all the attractions with least expense: under condition of the 11 sites identified, the problem is abstracted to a typical travelling salesman problem (TSP). We build a modified algorithm to suit our problem.

Model 2, visiting most attractions with given budget: In this model, we use reverse thinking by using method in the first model. We finally give the best plan by changing the numbers of visiting places.

Model 3, visiting most attractions with least expense within given time: It is the typical Multi-objective planning model. We give the time, travelling cost, the number of places and 0-1 variables constraints, resulting in planning the best family journey during different time period.

These three models almost meet all families' needs.

When thinking about the improvement of our models, we set up two modified model------ the model which considering the attraction's popularity and the comprehensive model which takes weather risk into consideration. In this way, we refine our design for the family travel.

Finally, we make a family travel packages consisting of 9 routes.

No.	name	time	route	Cost (yuan/person)
1	Weekend trip in Chengdu	2days	chengdu->qingchengshan-> dujiangyan->Chengdu	406
2	Tri-day trip in chengdu	3days	chengdu->leshan->dujiangyan-> qingchengshan->chengdu	623
3	4-day walk in sichuan	4days	Chengdu-dujiangyan->qingchengshan ->danba->leshan—>chengdu	949
4	5day trip to west Sichuan	5days	chengdu—>dujiangyan->qingcheng shan->danba->kangding->leshan—>chengdu	1206
5	6day luxurious trip to west sichuan	6days	chengdu->leshan->dujiagyan->qingchenshan-> danba->kangding->hjuanglong->chengdu	1533
6	All-view in Sichuan within 8 days	8days	chegdu—>leshan->hailuogou->kngading-> danba->siguniangshan->qingchengshan-> dujiangyan—>chengdu	1923
7	Deep view in 9 days	9days	chengdu->leshan->dujaingyan->qingchengshan-> danba->kangding->hailuogou->jiuzhaigou-> huanglong->chengdu	2389
8	Deep view in 10 days	10days	chengdu->leshan->dujaingyan>qingchengshan ->danba->kangding->hailuogou ->emeishan->jiuzhaigou->huanglong->chengdu	2783
9	All-view in Sichuan within 12 days	12days	Chengdu-leshan->emeishan-> hailuogou->kangding ->danba->siguniangshan-> qingchengshan->dujiangyan ->jiuzhaigou->huanglong—>chengdu	3242

Key words： refined circle, TCP, reverse thought, A multi-objective linear programming, traveling package

The Design of Family Summer Travelling Plan

1. Introduction

Summer holiday is always the best time to have a family journey. Parents usually bring their children to go on a trip in order to broaden their horizons and develop relationship between families.
Each family, however, has different needs for a journey, such as the number of family, the affordable expense, the time to travel, etc. choose a city as the destination, build a model considering the way of travel, the cost, the time and any other important factors.

2. The analysis of the problem

This problem is a discrete optimization problems under certain constraints. Our primary task is to determine different factors in the process of family travel. Then, we will emphasis on each of these factors, by building mathematic models.

Through the observation and survey on the network in everyday life, we found that when choosing travel plans, most families focus on three factors----vacation time, performance-to-price ratio, and the number of places to visit. Due to the actual situation of different family, we respectively use travel time and travel cost, as well as the number of tourist attractions, three variables which can be quantified, to elaborate the three aspects of family concerns, and respectively build mathematical models.

During the process of problem solving, we choose Chengdu and its surrounding attractions as our research object, namely is our family travel planning design of tour. We will establish three models to suit families of different needs.

Three models respectively view the number of tourist attractions, travel costs, travel time as a key consideration of family travel plan.

3. Assumptions

1. we take each family member equally, which means they will not have differences in travel costs and choices making.

2. we use cab as the only vehicle in our models. Data is referred to local travel agents.

3. the average speed of our cab is 50km per hour, while the average cost is 0.3 yuan per kilometer.

4. when we go from place A to place B, we have no visit to places during the trip.

5. during a time period, family members start from Chengdu, and end in Chengdu.

6. in a day, 12 hours for traveling and 12 hours for rest.

7. there is no accident in our travel.

8. we choose the following national 5A and 4A attractions as our potential destination after thinking about the surrounding tourist attractions: Chengdu, jiuzhaigou, huanglong, leshan, emeishan, siguniangshan, danba, dujiangyan, qingchengshan, hailuogou, kangding.

4. Introduction of the parameters

i , j ——number i site, number j site， i ， j =1，2，……，11；

They represent Chengdu, JiuZhaiGou, HuangLong, Leshan, EMeishan, SiGuNiangshan, Danba, DuJiaYan,QingChengShan,HaiLuoGou,KangDing,TianTaiShan,DaoChengYaDing；

c ——the average of total cost of a family member ；

t_i ——every family member spends t_i in number i site；

c_i ——each family member in the total consumption spots;；

t_{ij} ——from the spot to the attractions journey time required；

c_{ij} ——transport costs from the scenic spots to the attractions;

$$r_{ij} = \begin{cases} 1 & from \quad i \quad to \quad j \\ 0 & else \end{cases}$$

5. Establishment of the model and models' solving

5.1 Model Ⅰ visiting all the attractions with least expense

5.1.1 Brief introduction to the model

In this model, we will discuss family in bound for all 11 scenic spots under the condition of the formation of the least expensive. Under the condition of the 11 sites identified, 11 scenic area can be as 11 points, the problem is abstracted to a typical traveling salesman problem (TSP).

5.1.2 Establishment of the model

We can abstract the family trip problem to the following questions:

A businessman wants to n city to sell the goods, starting from a particular city, along the way after each city a return to the departure city, to determine a walking route, shortest route. Is the traveling salesman problem (TSP).In terms of graph theory, is an empowerment in the diagram, completely find out the right to a minimum Hamilton circle. Say this is the optimal times. Contrary to the short circuit and attachment problems, although there is currently no effective algorithm to solve traveling salesman problem. But there is a feasible way is to ask a Hamilton ring, then the appropriate modification to get another Hamilton circle with a smaller right. Modified method called improved algorithm.

Suppose $C = v_1 v_2 \cdots v_n v_1$。

For $1 < i+1 < j < n$, we create a new Hamilton circle

$C_{ij} = v_1 v_2 \cdots v_i v_j v_{j-1} v_{j-2} \cdots v_{i+1} v_{j+1} v_{j+2} \cdots v_n v_1$,

It is derived from deleting $v_i v_{i+1}$ and $v_j v_{j+1}$ and adding $v_i v_j$ and $v_{i+1} v_{j+1}$. If $w(v_i v_j) + w(v_{i+1} v_{j+1}) < w(v_i v_{i+1}) + w(v_j v_{j+1})$, we substitute C with C_{ij} ,which is called the refined circle.

However, results using the improved circle algorithm are almost certainly not optimal. In order to get higher accuracy, on the premise of not given the starting position, can choose different initial circle, repeated n times algorithm, to obtain accurate results.

Thus, we use the mathematical expression of the abstract:

Suppose there are n cities, d_{ij} is the distance between i and j , $t_{ij} = 0 or 1$ where,

0 means the way has been taken, 1 means the way has not been selected.

Thus, we have

$$\min \sum_{i=1}^{n} d_{ij} x_{ij}$$

$$s.t. \sum_{i=1}^{n} x_{ij} = 1, i = 1, 2, ..., n$$

$$\sum_{j=1}^{n} x_{ij} = 1, x = 1, 2, ..., n$$

$$\sum_{i,j \in s}^{n} x_{ij} \le |s| - 1, 2 \le |s| \le n-1, s \subset \{1, 2, ..., n\}$$

5.1.3 Model's solving

In our model one, we will travel the weight value of business model "the shortest distance" changes for the "least cost".

Using the piecewise function below to find the minimum cost matrix

$$F(i,j)_{11\times 11}=\begin{cases} F(i,j)=d(i,j)\times 1.5, & d(i,j)<=500 \\ F(i,j)=1.4\times d(i,j), & 500<d(i,j)<=1000 \\ F(i,j)=1.1\times d(i,j), & 1000<d(i,j) \end{cases}$$

Thus, with LINGO help, we figure out the best route is

chengdu—>leshan->emei->hailuogou->kangding->danba->siguniang shan->qingchen shan->dujiangyan->jiuzhaigou->huanglong—>chengdu

with cost of 3242.4yuan

5.2 Model Ⅱ visiting most attractions with given budget

5.2.1 Brief introduction to the model

In this model, we will consider family's economy condition as the first concern. We will figure out the most number of attractions a family can visit under certain budget.

5.2.2 Establishment of the model

In the realizing process, we will reverse our thought and respectively figure out the least expense of visiting n (n=2,3,…11) attractions. And then, we will set a family's budget according to the results. Finally, we will give the number of attractions under the given budget.

In order to realize this model, we can still use the TSP problem and change the number of the city to calculate the least expense needed. Therefore, this model is similar to the former one.

5.2.3 Model’s solving

Through calculation, the least expenses of visiting n attractions is as below

number	3	4	5	6	7	8	9	10	11
expense	405.4	623.2	949.1	1206.3	1533.6	1923.6	2389.8	2783.4	3242.4

Thus, we get following travel lanes as below.

When the budget is 800 per person, we recommend 3~4 attractions, including

chengdu->qingchengshan->dujiangyan->chengdu

chengdu->leshan->qingchengshan->dujiangyan->chengdu

When the budget is 1500 per person, we recommend 5~6 attractions, including

Chengdu—>dujingyan->qingchenshan->danba->leshan—>chengdu

chengdu—>dujiangyan->qingchengshan->danba->kangding->leshan—>chengdu

When the budget is 2000 per person, we recommend 7~8 attractions, including

chengdu-leshan->hailuogou->kangding->danba->qingchengshan->dujiangyn—>Chengdu

Chengdu-leshan->hailuogou->kangding->danba->siguniangshan->qingchengshan->dujiangyan—>chengdu

When the budget is 2500 per person, we recommend 9~10 attractions, including

Chengdu-huanglong->qingchengshan->dujiangyan->siguniangshan->danba->kanding->hailuogou->leshan—>Chengdu

When the budget is 3500per person, we recommend 11 attractions, including

Chengdu->leshan->emeishan->hailuogou->kangding->danba>siguniangshan->qingchengshan->dujiangyan->jiuzhaigou->huanglong—>chengdu

5.3 Model Ⅲ visiting most attractions with least expense within given time

5.3.1 Brief introduction to the model

Fewest expenses and most tourist attractions visited are two seperated goals.So,firstly we assume number of tourist attractions to be visited and then figure out the fewest expense under certain limit.In this way,we will find several ‘comfortable’ plans.Certain family can take one of them on their own.

5.3.2 Establishment of the model

We assume: the total cost of travel is composed of 2 parts, respectively, the total cost and the cost of transportation in tourist attractions. We define:

Each member of the family to travel -- average total cost;

Each member of the family -- the average total cost of transportation;

-- each family member on the average cost of tourist attractions;

In order to get the objective function: Min $m = m_1 + m_2$

(1) the total cost of transportation

Because the representation from the scenic spots to the spots of transportation costs, but rather the judgment whether the delegates directly to a 0 - 1 variables the spots from the scenic spots, so we can easily get the traffic cost:

$$m_1 = \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times c_{ij}$$

(2) cost of tourist attractions

Because of that family members in the total consumption spots, also can show whether family members to the article and the scenic spots, so actually family members in the to to the attractions of the cost calculation for two times, spend so we have tourist attractions for:

$$m_2 = \frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times \left(c_i + c_j\right)$$

Thus we can obtain the objective function:

Min $\quad m = m_1 + m_2$

$$= \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times c_{ij} + \frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times \left(c_i + c_j\right)$$

Obviously, travel costs associated with the use of time and the number of attractions, this requires a certain constraints on our target function:

1) time constraints

We assume that the total time for family planning in Sichuan tourism is T.According to the model assumptions, said from the spot to the attractions journey time required, so the total time required for the said road

$$\sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times t_{ij} \ ;$$

family in the scenic tour time,. $\frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times \left(t_i + t_j\right)$

so the family in the time always stay tourist attractions for.

$$\sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times t_{ij} + \frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times \left(t_i + t_j\right) \le \mathrm{T}$$

2) tourist attractions number constraint

According to the hypothesis, the travel route is annular, namely the final home to return to Chengdu, so that the number of delegates to the tourist attractions,

$$\sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij}$$

here we assume to tourist attractions for the number of n（n=2，3，……，13）. So the number of constraints as tourist attractions:

$$\sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} = n \qquad (n=2, 3, \ldots\ldots, 13)$$

3) 0 - 1 variable constraint

We can put all the attractions are joined in a circle, and each of the spots as the last point circle. All spots constitute tourist route map is a directed graph.All of the attractions must form an Euler Ian circuit, thus restricting: n（n=2，3，……，13）

At that time, because the Chengdu is the starting point, so $\sum_{i=1} r_{ij} = 1$;

When going back to Chengdu, because in the end, so. $\sum_{j=1} r_{ij} = 1$

Comprehensive above knowable,

$$\sum_{i} r_{ij} = \sum_{j} r_{ij} \le 1 \qquad (i,\ j=1, 2, \ldots\ldots, 13)$$

$$\sum_{i=1} r_{ij} = 1 \qquad \sum_{j=1} r_{ij} = 1$$

Similarly, when, when, according to the hypothesis three $r_{ij} = r_{ji} = 1$ is not possible.

So we can get constraint:

$$r_{ij} \times r_{ji} = 0 \qquad (i,\ j=2, 3, \ldots\ldots, 13)$$

In summary, we establish the mathematical model for the:

Min $\quad m = m_1 + m_2$

$$= \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times c_{ij} + \frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times (c_i + c_j)$$ Constraint conditions:

$$\begin{cases} \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times t_{ij} + \frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times (t_i + t_j) \le \mathrm{T} \\ \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} = n \qquad (n=2, 3, \ldots\ldots, 13) \\ \sum_{i} r_{ij} = \sum_{j} r_{ij} \le 1 \qquad (i,\ j=1, 2, \ldots\ldots, 13) \\ \sum_{i=1} r_{ij} = 1 \qquad \sum_{j=1} r_{ij} = 1 \end{cases}$$

5.3.3 Model's solving

Here we introduce the following notation:

The distance between the spots -- and the spots;

The average speed of the family -- ride a tour bus, =50km/h;

The average cost of a home -- the tour bus, =0.3 /h;

We can get the specific value, according to the formula $t_{ij} = d_{ij} / v$， t_{ij} can be obtained from the same, according to the formula $c_{ij} = d_{ij} \times m$ can be the corresponding （n=2，3，……，11） and numerical values of the appendix

Similarly, for consultation by some travel to Sichuan, we draw the delegates at the conference in time for the best attractions and their total consumption in the scenic spots:

t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}
7	24	18	12	36	30	12	9	15	24	17

(unit: hour)

c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}	c_{11}
120	423	300	135	378	390	175	90	148	303	241

(unit: yuan)

According to the model, the use of Lingo programming, the results are listed in the following table:

Tourist n	2	3	4
Total cost m	250	406	623
Routine	1→8→1	1→9→8→1	1→4→8→9→1

Tourist n	5	6
Total cost m	949	1207
Routine	1→8→9→7→4→1	1→4→11→12→9→8→1

Tourist n	7
Total cost m	1534
Routine	1→4→10→11→12→9→8→1

(the number 1 - 13 respectively, Chengdu, Jiuzhaigou, Huanglong, Leshan, Emei, Four Girls Mountain, Danba, Dujiangyan, Qingchengshan, Hailuogou,Kangding, Tiantai Mountain, Daocheng, Aden)

For the above results, we recommend to:

Route one: Chengdu - Leshan - Dujiangyan - Qingchengshan - Chengdu

Tourist attractions: 4 per capita fee

6. The improvement of our models

6.1 aspects of improving

1. In reality, between two places of interest, there are other ways for travel besides cabs, such as airplane, railway. Results will be more reasonable if these are considered.

2. There may be little child and the elderly in a family, who will have different needs for travelling.

3. There may be omissions for the different needs of families traveling in this model .Realistic choice will be made according to family members' attractions, costs and time when planning the trip.

4. Compared to actual travel, weather factors are not considered in these models. The weather is a very important travel itinerary objective factor. We can add weather to improve our models.

6.2 The improved model Ⅰ： compromised model by considering the popularity of the attractions

6.2.1 Brief introduction to the model

In this improved model, we will identify the rating function of different attractions according to the family members’ favor and different popularity of each attraction and we will figure out more satisfying travel plans.

6.2.2 Model

Step 1：rating function

chengdu(4)、jiuzhai(5)、huanglong(4)、leshan(3)、emei(4)、siguniangshan(4)、danba(3)、dujiangyan(3)、qingchengshan(3)、hailuogou(4)、kangding(4)

According to the tour agency and country's relating criteria, we get the rating matrix of the 11 attractions

$$A=\left[4,5,4,3,4,4,3,3,3,4,4\right]$$

Then we use $W_i=\frac{sum(A)}{A_i}$ to calculate the score of each attraction（the lower the score is, the more popular the attraction is），

$$w=\left[10.25,8.2,10.25,13.67,10.25,10.25,13.67,13.67,13.67,10.25,10.25\right]$$

Step 2：target function:

$$\text{Min}\quad m=m_1+m_2$$

$$=\sum_{i=1}^{11}\sum_{j=1}^{11}r_{ij}\times c_{ij}+\frac{1}{2}\times\sum_{i=1}^{11}\sum_{j=1}^{11}r_{ij}\times\left(c_i+c_j\right)$$

Step 3：constraints:

This part is similar to the former part, so we will not state it again.

6.2.3 Model solution and the results of analysis

We recommend the following route

To visit 5 attractions,

Chengdu-leshan-dujiangyan-qingchengshan-danba-chengdu

To visit 6 attractions,

Chengdu-leshan-dujiangyan-qingchengshan-danba-kangding-chengdu

To visit 7 attractions,

Chengdu-leshan-dujiangyan-qingchengshan-danba-kangding-huanglong-chengdu

To visit 8 attractions,

Chengdu-leshan-dujiangyan-qingchengshan-danba-kangding-hailuogou-huanglong-chengdu

To visit 9 attractions,

Chengdu-leshan-dujiangyan-qingchengshan-danba-kangding-hailuogou-jiuzhaigou-huanglong-chengdu

To visit 10 attractions,

Chengdu-leshan-dujiangyan-qingchengshan-danba-kangding-hailuogou-emeishan-jiuzhaigou-huanglong-chengdu

6.3 The improved modelⅡ: compromised model by considering the weather risk

6.3.1 Extra symbols

l——the lost brought by rainy weather

$c(n)_{\min}$——the minimum cost on traveling n places

$c(n)_{\max}$——the maximum cost on traveling n places

$l(n)_{\min}$——the minimum lost by rainy days through n places

$l(n)_{\max}$——the maximum lost by rainy days through n place

6.3.2 re-analysis of problem

This model adds the factor of rainy weather on the base of the third model, namely adding an goal that is to lower the lost brought by rainy weather. We define the travel lost as the total chances of rainy weather.

6.3.3 Data processing

（1)By finding relevant data,we draw11attractionsprobability of precipitation in summer within 10 days

$[P_{is}]_{11\times 10}=$

0.15	0.1	0.3	0.8	0.7	0.5	0.6	0.3	0.1	0
1	0.8	0.8	0.5	0.5	0.4	0.5	0.6	0.3	0.2
0.5	1	0.9	1	0.3	0	0.2	0	0.4	0.4
0.1	0	0.1	0.5	0.5	0.7	0.3	0.3	0.1	0.1
0.3	0.4	0.4	0.6	0.3	0.3	0.2	0.4	0.6	0.6
0.6	0.6	0.6	0.5	0.8	0.3	0.1	0.1	0.1	1
0.3	0.2	0.2	0.1	0	0.1	0.1	0.2	0.2	0.3
0.4	0.3	0.3	0.2	0.4	0.9	0.9	0.9	0.8	0.8
0.5	0.3	0.3	0.4	0.3	0.8	1	0.9	0.9	0.9
0.2	0.6	0.6	0.4	0.1	0	0.8	0.7	0.6	0.4
0.1	0.1	0.3	0.3	0.5	0.6	0.8	0.7	0.63	0.4

（2）Normalized data

By observing the data, we found that the gap between the value of total tourism spending and rainy weather caused the loss of a large tourism, both in the use of comprehensive set goals, in order to avoid the effects of the use of common data processing methods - poor variation method, The data do normalized. Namely：

$$C = \frac{c - c(n)_{\min}}{c(n)_{\max} - c(n)_{\min}} \quad ; \quad L = \frac{l - l(n)_{\min}}{l(n)_{\max} - l(n)_{\min}}$$

（3）Objective function

our approach is to meet the corresponding constraints, first determine the number of places to visit, and then were shown the corresponding total cost of travel and tourism losses caused by rainy weather normalization for the minimum weight after treatment. This will eventually come to some the best solution, but organizers can choose according to their own situation. Whereby the final objective function:

$$\text{Min} \quad Q = \gamma_1 \times C + \gamma_2 \times L$$

(where C,L are mentioned above, γ_1 γ_2 are the weights and $\gamma_1 + \gamma_2 = 1$)

Ⅰ.for C:

$$c = 100 \times \sum_{i=1}^{11}\sum_{j=1}^{11} \lambda_i \times r_{ij} \times c_{ij} + \frac{1}{2} \times 100 \times \sum_{i=1}^{11}\sum_{j=1}^{11} \lambda_i \times r_{ij} \times (c_i + c_j)$$

$c(n)_{\min}$ and $c(n)_{\max}$ can be measured by our pervious model.

Ⅱ.for L：

P_{is}——the chance of rainy days at the i^{th} attraction(s=1，2，……10）

T_i——the time spend to arrive at the i^{th} attraction;

V——the group of the places to visit

therefore，$l = \sum_{i \in V} \sum_{s=[T_I]}^{[T_I + t_i]} P_{is}$ ，

Constraints

①time

To simplify the model, we assume that tourism in Sichuan lasts not more than 10 days, but the time is included in the road time and time stay at tourist attractions. t_{ij} represents the time spend from the i^{th} attraction to the j^{th} attraction，so the total time is $\sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times t_{ij}$ ； t_i represents the time family spend in the i^{th} attraction，so the total time is $\frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times (t_i + t_j)$。 so：

$$\sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times t_{ij} + \frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times (t_i + t_j) \le 120$$

②the number of places

$$\sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} = n \quad (n=2, 3, \ldots\ldots, 11)$$

③0——1 variables

We can put all the attractions together into a circle, and the circle on each one seen as a point of interest.For each point,only all owed to enter up to one side, the same side only allows a maximum of one out,and as long as there is an edge to enter is to have an edge out.So you can get the constraint:

$$\sum_{i} r_{ij} = \sum_{j} r_{ij} \le 1 \qquad (i, \; j=1, 2, \ldots\ldots, 11)$$

Where $i = 1, \sum_{i=1} r_{ij} = 1$;

where $j = 1, \sum_{j=1} r_{ij} = 1$。

Therefore,

$$\sum_{i} r_{ij} = \sum_{j} r_{ij} \le 1 \qquad (i, \; j=1, 2, \ldots\ldots, 11)$$

$$\sum_{i=1} r_{ij} = 1 \qquad \sum_{j=1} r_{ij} = 1$$

Samely, where i, $j \ge 2$

$$r_{ij} \times r_{ji} = 0 \qquad (i, \; j=2, 3, \ldots\ldots, 11)$$

④T_i

$$T_i = T_{i-1} + t_{i-1,i} \qquad (i=2, 3, \ldots\ldots, 11)$$

6.3.4 Model:

Min $\quad Q = \gamma_1 \times C + \gamma_2 \times L$

Constraints:

$$\begin{cases} \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times t_{ij} + \frac{1}{2} \times \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} \times (t_i + t_j) \le 120 \\ \sum_{i=1}^{11}\sum_{j=1}^{11} r_{ij} = k \end{cases}$$

$$\sum_i r_{ij} = \sum_j r_{ij} \le 1 \qquad (i,\ j=1,\ 2,\ \ldots\ldots,\ 11)$$

$$r_{ij} \times r_{ji} = 0 \qquad (i,\ j \ge 2)$$

$$T_i = T_{i-1} + t_{i-1,i} \qquad (i=2,\ 3,\ \ldots\ldots,\ 11)$$

6.3.4 Model solution and the results of analysis:

$\gamma_1 = 0.6, \gamma_2 = 0.4$

Expense per person	loss
965	1.7
Route:1→11→7→4→8→1	

$\gamma_1 = 0.4, \gamma_2 = 0.6$

Expense per person	loss
1028	1.6
Route ：1→7→9→8→4→1	

$\gamma_1 = 0.7, \gamma_2 = 0.3$

Expense per person	loss
946	1.8
Route：1→10→11→7→4→1	

$\gamma_1 = 0.3, \gamma_2 = 0.7$

Expense per person	loss
1206	0.9
Route ：1→11→9→8→4→1	

$\gamma_1 = 0.5, \gamma_2 = 0.5$

Expense per person	loss
987	1.6
Route：1→11→9→8→4→1	

（where 1—11represent Chengdu jiuzhai huanglong leshan emei siguniangshan danba dujiangyan qingchengshan hailuogou kangding ）

From these results, we recommend a way :chengdu→kangding→qingchengshan→dujiangyan→leshan→chengdu ， the average cost is 937 yuan, the lost brought by rainy days is 1.6

8. Recommendation for the family summer travel plan

In this part, we will give several travel routes for the potential customers.

No.	name	time	route	Cost(yuan/person)
1	Weekend trip in Chengdu	2days	chengdu->qingchengshan-> dujiangyan->Chengdu	406
2	Tri-day trip in chengdu	3days	chengdu->leshan->dujiangyan-> qingchengshan->chengdu	623
3	4-day walk in sichuan	4days	Chengdu-dujiangyan->qingchengshan ->danba->leshan—>chengdu	949
4	5day trip to west Sichuan	5days	chengdu—>dujiangyan->qingcheng shan->danba->kangding->leshan—>chengdu	1206
5	6day luxurious trip to west sichuan	6days	chengdu->leshan->dujiagyan->qingchenshan-> danba->kangding->hjuanglong->chengdu	1533
6	All-view in Sichuan within 8 days	8days	chegdu—>leshan->hailuogou->kngading-> danba->siguniangshan->qingchengshan-> dujiangyan—>chengdu	1923
7	Deep view in 9 days	9days	chengdu->leshan->dujaingyan->qingchengshan-> danba->kangding->hailuogou->jiuzhaigou-> huanglong->chengdu	2389
8	Deep view in 10 days	10days	chengdu->leshan->dujaingyan>qingchengshan ->danba->kangding->hailuogou ->emeishan->jiuzhaigou->huanglong->chengdu	2783
9	All-view in Sichuan within 12 days	12days	Chengdu-leshan->emeishan-> hailuogou->kangding ->danba->siguniangshan-> qingchengshan->dujiangyan ->jiuzhaigou->huanglong—>chengdu	3242

Reference

[1]王振龙，时间序列分析，北京：中国统计出版社，2002 年。
[2]韩中庚，长江水质综合评价与预测的数学模型，工程数学学报第 22 卷第 7 期：P47-P52，2005 年
[3] 张超，杨奕，李嵩，关于灾情巡视路线的模型：1～3 页，1998。
[4] 耿素云，集合论与图论，北京：北京大学出版社，1998。
[5] 边馥萍，侯文化，梁冯珍，北京：高等教育出版社，2005。
[6] 赵静 但琦, 数学建模与数学实验,高等教育出版社,2001;
[7]栗雪娟，崔尚森，张柯，最佳旅游路线选择的神经网络方法，交通与计算机 2006 年第 5 期 第 24 卷 总 132 期
[8][日]田村坦之，系统工程，北京：科学出版社，2001
[9]姜启源 谢金星 叶俊,《数学模型（第三版）》,北京:高等教育出版社,2003。
[10]谢金星 薛毅，《优化建模与 LINDO/LINGO 软件》，北京：清华大学出版社，2005。
[11]李庆扬 王能超 易大义，《数值分析》，北京：清华大学出版社 施普林格出版社，2001

Appendix

模型一程序：

```
clc,clear
%主函数：
function main
load mydata
global d
d=zeros(11);
C=zeros(11,13);
for i=1:11
for j=1:11
d(i,j)=0.3*t(i,j);
end
end
[i,j,y]=find(d);
a=sparse(i,j,y);
a=tril(a);
L=size(d,1)
for i=1:11
c1=[i 1:11 11];
[circle,long]=modifycircle(c1,L);
c2=[i 11 1:11];%改变初始圈，该算法的最后一个顶点不动
[circle2,long2]=modifycircle(c2,L);
if long2<long
long=long2;
```

```
circle=circle2;
end
changdu(i)=long;
C(i,:)=circle;
circle,long
end
[zuiyou,I]=min(changdu);
circle0=C(I,:)
x=[x0(circle0(1:end-1)) x0(51)];
y=[y0(circle0(1:end-1)) y0(51)];
scatter(x,y,'*')
%被调用函数：
function [circle,long]=modifycircle(c1,L);
global d
flag=1;
while flag>0
flag=0;
for m=1:L-3
for n=m+2:L-1
if d(c1(m),c1(n))+d(c1(m+1),c1(n+1))<...
d(c1(m),c1(m+1))+d(c1(n),c1(n+1))
flag=1;
c1(m+1:n)=c1(n:-1:m+1);
end
end
end
end
long=d(c1(1),c1(L));
for i=1:L-1
long=long+d(c1(i),c1(i+1));
end
circle=c1;
```

模型二程序：

```
sets:
jingdian/1..11/:c,t,l;
!其中：1,2,...,11 分别代表成都、九寨沟、黄龙、乐山、峨嵋、四姑娘山、丹巴、都江堰、青城山、海螺沟、康定；c，t 分别表示旅行团在各景点的吃住消费和逗留时间;；l 是为了控制不出现两个以上环形回路而设的一个变量;
links(jingdian,jingdian):r,cc,tt;
!其中：r 为 0-1 变量（0 表示两景点不相连，1 表示两景点相通）；cc 为两景点之间的交通费用；tt 为两景点之间的交通时间;
endsets
```

```
data:
t=7 24 18 12 36 30 12 9 15 24 17;
c=120 423 300 135 378 390 175 90 148 303 241;
tt=0 8.54 4.74 2.82 3.44 5.08 8.4 1.32 1.54 6.14 6.6
8.54 0 1.22 11.52 12.14 10.9 13.1 8.84 8.98 14.84 15.54
4.74 1.22 0 11.22 11.82 9.38 11.58 7.66 7.46 13.44 13.9
2.82 11.52 11.22 0 0.88 7.78 8.08 4.02 4.24 5.84 6.3
3.44 12.14 11.82 0.88 0 8.42 8.24 4.66 4.88 6 6.46
5.08 10.9 9.38 7.78 8.42 0 2.18 4.24 4.04 5.98 6.74
8.4 13.1 11.58 8.08 8.24 2.18 0 6.08 6.22 3.86 2.86
1.32 8.84 7.66 4.02 4.66 4.24 6.08 0 0.3 6.28 6.74
1.54 8.98 7.46 4.24 4.88 4.04 6.22 0.3 0 6.08 6.54
6.14 14.84 13.44 5.84 6 5.98 3.86 6.28 6.08 0 2.08
6.6 15.54 13.9 6.3 6.46 6.74 2.86 6.74 6.54 2.08 0;
!其中：主对角线为零,表示各景点到自身交通费用为零;
cc=0128 71 42 52 77 126 20 23 92 99
128 0 18 173 182 164 197 133 135 223 233
71 18 0 168 177 141 174 115 112 202 209
42 173 168 0 13 117 121 60. 64 88 95
52 182 177 13 0 126 124 70 73 90 97
76 164 141 117 126 0 33 64 61 90 101
126 197 174 121 124 33 0 91 93 58 43
20 133 115 60 70 64 91 0 5 94 101
23 135 112 64 73 61 93 5 0 91 98
92 223 202 88 90 90 58 94 91 0 31
99 233 209 95 97 101 43 101 98 31 0;
!其中：主对角线为零,表示各景点到自身的交通时间为零;
enddata
min=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(cc(i,j)+0.5*(c(i)+c(j)))));
!目标函数：表示计划游玩的景点数目为 n 时的最小费用;
@for(jingdian(i):r(i,i)=0);
!约束条件：表示各景点到自身没有路线相连的约束条件;
@for(jingdian(i)|i#ge#2:@for(jingdian(j)|j#ge#2:r(i,j)+r(j,i)<1));
!约束条件：表示除起点（成都）外，若旅行团从景点 i 到景点 j 去游玩（即 r(i,j)=1），则不会再从景点 j 到景点 i 去游玩（即 r(j,i)=0），也就是说除起点外每个景点只游玩一次;
a=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+0.5*(t(i)+t(j)))));
@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+0.5*(t(i)+t(j)))))<360;
!约束条件:表示总的旅行时间（交通时间和景点逗留时间）不超过给定时间 30 天 360 小时;
@for(jingdian(i):@sum(jingdian(j):r(i,j))=@sum(jingdian(j):r(j,i)));
@for(jingdian(i)|i#eq#1:@sum(jingdian(j):r(i,j))=1);
@for(jingdian(i)|i#ne#1:@sum(jingdian(j):r(i,j))<1);
!这三个约束条件：表示起点（成都）有且仅有一条路线出去和一条路线进来，其它景点要么有且仅有一条路线出去和一条路线进来，要么既没有路线出去也没有路线进来;
@for(links:@bin(r));
```

!约束条件:表示 0-1 变量约束;
@sum(jingdian(j):@sum(jingdian(i):r(i,j)))=11;
!约束条件:表示旅游景点的数目为 n 的约束;
@for(jingdian(i):@for(jingdian(j)|j#gt#1#and#j#ne#i:l(j)>=l(i)+r(i,j)-(n-2)*(1-r(i,j))+(n-3)*r(j,i)));
@for(jingdian(i)|i#gt#1:l(i)<n-1-(n-2)*r(1,i);l(i)>1+(n-2)*r(i,1));
!这两个约束条件：为了控制不出现两个以上环形回路，保证有且仅有一条环形路线；

模型三程序：
sets:
jingdian/1..11/:c,t,l;
!其中：1,2,...,13 分别代表成都、九寨沟、黄龙、乐山、峨嵋、四姑娘山、丹巴、都江堰、青城山、海螺沟、康定；c，t 分别表示旅行团在各景点的吃住消费和逗留时间；w 表示各景点选择性权重；l 是为了控制不出现两个以上环形回路而设的一个变量;
links(time,time):r,feijing,shijian;
!其中：r 为 0-1 变量（0 表示两景点不相连，1 表示两景点相通）；feiyong 为两景点之间的交通费用；shijian 为两景点之间的交通时间;
endsets
data:
t=7 24 18 12 36 30 12 9 15 24 17;
c=120 423 300 135 378 390 175 90 148 303 241;
shijian=0 8.54 4.74 2.82 3.44 5.08 8.4 1.32 1.54 6.14 6.6
8.54 0 1.22 11.52 12.14 10.9 13.1 8.84 8.98 14.84 15.54
4.74 1.22 0 11.22 11.82 9.38 11.58 7.66 7.46 13.44 13.9
2.82 11.52 11.22 0 0.88 7.78 8.08 4.02 4.24 5.84 6.3
3.44 12.14 11.82 0.88 0 8.42 8.24 4.66 4.88 6 6.46
5.08 10.9 9.38 7.78 8.42 0 2.18 4.24 4.04 5.98 6.74
8.4 13.1 11.58 8.08 8.24 2.18 0 6.08 6.22 3.86 2.86
1.32 8.84 7.66 4.02 4.66 4.24 6.08 0 0.3 6.28 6.74
1.54 8.98 7.46 4.24 4.88 4.04 6.22 0.3 0 6.08 6.54
6.14 14.84 13.44 5.84 6 5.98 3.86 6.28 6.08 0 2.08
6.6 15.54 13.9 6.3 6.46 6.74 2.86 6.74 6.54 2.08 0;
!主对角线为零,表示各景点到自身交通费用为零;
feiyong=0 128.1 71.1 42.3 51.6 76.2 126 19.8 23.1 92.1 99
128.1 0 18.3 172.8 182.1 163.5 196.5 132.6 134.7 222.6 233.1
71.1 18.3 0 168.3 177.3 140.7 173.7 114.9 111.9 201.6 208.5
42.3 172.8 168.3 0 13.2 116.7 121.2 60.3 63.6 87.6 94.5
51.6 182.1 177.3 13.2 0 126.3 123.6 69.9 73.2 90 96.9
76.2 163.5 140.7 116.7 126.3 0 32.7 63.6 60.6 89.7 101.1
126 196.5 173.7 121.2 123.6 32.7 0 91.2 93.3 57.9 42.9
19.8 132.6 114.9 60.3 69.9 63.6 91.2 0 4.5 94.2 101.1
23.1 134.7 111.9 63.6 73.2 60.6 93.3 4.5 0 91.2 98.1

```
92.1 222.6	201.6	87.6 90	89.7 57.9 94.2 91.2 0	31.2
99	233.1	208.5	94.5 96.9 101.1	42.9 101.1	98.1 31.2 0;
!主对角线为零,表示各景点到自身的交通时间为零;
n=?;
T=?;
!其中：n 表示计划游玩的景点数目;
!T 表示家庭游玩的时间
enddata
min=@sum(time(j):@sum(time(i):r(i,j)*(cc(i,j)+0.5*(c(i)+c(j)))));
!表示计划游玩的景点数目为 n 时的最小费用;
@for(time(i):r(i,i)=0);
!约束条件：表示各景点到自身没有路线相连的约束条件;
@for(time(i)|i#ge#2:@for(time(j)|j#ge#2:r(i,j)+r(j,i)<1));
!约束条件：表示除起点（成都）外，若旅行团从景点 i 到景点 j 去游玩（即 r(i,j)=1），则不会再从景点 j 到景点 i 去游玩（即 r(j,i)=0），也就是说除起点外每个景点只游玩一次;
a=@sum(time(j):@sum(time(i):r(i,j)*(time(i,j)+0.5*(t(i)+t(j)))));
@sum(v(j):@sum(v(i):r(i,j)*(time(i,j)+0.5*(t(i)+t(j)))))<T;
!表示总的旅行时间（交通时间和景点逗留时间）不超过给定时间 T;
@for(time(i):@sum(time(j):r(i,j))=@sum(time(j):r(j,i)));
@for(time(i)|i#eq#1:@sum(time(j):r(i,j))=1);
@for(time(i)|i#ne#1:@sum(time(j):r(i,j))<1);
!表示起点（成都）有且仅有一条路线出去和一条路线进来，其它景点要么有且仅有一条路线出去和一条路线进来，要么既没有路线出去也没有路线进来;
@for(links:@bin(r));
!约束条件:表示 0-1 变量约束;
@sum(time(j):@sum(time(i):r(i,j)))=n;
!约束条件:表示旅游景点的数目为 n 的约束;
@for(time(i):@for(time(j)|j#gt#1#and#j#ne#i:l(j)>=l(i)+r(i,j)-(n-2)*(1-r(i,j))+(n-3)*r(j,i)));
@for(time(i)|i#gt#1:l(i)<n-1-(n-2)*r(1,i);l(i)>1+(n-2)*r(i,1));
!为了控制不出现两个以上环形回路，保证有且仅有一条环形路线;
```

改进模型一程序：

```
sets:
jingdian/1..11/:c,t,w,l;
!其中：1,2,...,11分别代表成都、九寨沟、黄龙、乐山、峨嵋、四姑娘山、丹巴、都江堰、青城山、海螺沟、康定；c，t分别表示旅行团在各景点的吃住消费和逗留时间；w表示各景点选择性权重；l是为了控制不出现两个以上环形回路而设的一个变量;
links(jingdian,jingdian):r,cc,tt;
!其中：r为0-1变量（0表示两景点不相连，1表示两景点相通）；cc为两景点之间的交通费用；tt为两景点之间的交通时间;
endsets

data:
```

```
t=7 24 18 12 36 30 12 9 15 24 17;!其中:t(1)=0,表示在成都的逗留时间为0, 因为相对旅行团而言, 由于成都既是起点又是终点, 并未在成都游玩;
c=120 423 300 135 378 390 175 90 148 303 241;!其中: c(1)=0, 表示在成都的吃住费用算做, 理由同上;
w=10.25 8.2 10.25 13.67 10.25 10.25 13.67 13.67 13.67 10.25 10.25;
tt=0    8.54    4.74    2.82    3.44    5.08    8.4 1.32    1.54 6.14   6.6
8.54 0  1.22    11.52   12.14   10.9    13.1    8.84    8.98    14.84   15.54
4.74 1.22   0   11.22   11.82   9.38    11.58   7.66    7.46    13.44   13.9
2.82 11.52  11.22   0   0.88    7.78    8.08    4.02    4.24    5.84    6.3
3.44    12.14   11.82   0.88    0   8.42    8.24    4.66    4.88    6   6.46
5.08 10.9   9.38    7.78    8.42    0   2.18    4.24    4.04    5.98    6.74
8.4 13.1    11.58   8.08    8.24    2.18    0   6.08    6.22    3.86    2.86
1.32    8.84    7.66    4.02    4.66    4.24    6.08    0   0.3 6.28    6.74
1.54    8.98    7.46    4.24    4.88    4.04    6.22    0.3 0   6.08    6.54
6.14    14.84   13.44   5.84    6   5.98    3.86    6.28    6.08    0   2.08
6.6 15.54   13.9    6.3 6.46    6.74    2.86    6.74    6.54    2.08    0;
!其中: 主对角线为零,表示各景点到自身交通费用为零;
cc=0    128   71    42  52  77  126 20  23  92  99
128 0   18    173   182  164    197 133 135 223 233
71  18  0   168 177 141 174 115 112 202 209
42  173 168 0   13  117   121   60. 64  88  95
52  182 177 13  0   126 124 70  73  90  97
76  164  141    117 126 0   33  64  61  90  101
126 197     174 121 124 33  0   91  93  58  43
20  133 115 60  70  64  91  0   5   94  101
23  135 112 64  73  61  93  5   0   91  98
92  223 202 88  90  90  58  94  91  0   31
99  233 209 95  97  101 43  101 98  31  0;
!其中: 主对角线为零,表示各景点到自身的交通时间为零;
n=?;!其中: n表示计划游玩的景点数目;
enddata
min=@sum(jingdian(j):@sum(jingdian(i):100*w(j)*r(i,j)*(cc(i,j)+0.5*100*(c(i)+c(j)))));!目标函数: 表示计划游玩的景点数目为n时的
最小费用;
b=@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(cc(i,j)+0.45*(c(i)+c(j)))));
@for(jingdian(i):r(i,i)=0);!约束条件: 表示各景点到自身没有路线相连的约束条件;
@for(jingdian(i)|i#ge#2:@for(jingdian(j)|j#ge#2:r(i,j)+r(j,i)<1));!约束条件: 表示除起点(成都)外, 若旅行团从景点i到景点j去游玩(即r(i,j)=1), 则不会再从景点j到景点i去游玩(即r(j,i)=0), 也就是说除起点外每个景点只游玩一次;
@sum(jingdian(j):@sum(jingdian(i):r(i,j)*(tt(i,j)+0.5*(t(i)+t(j)))))<240;! 约 束条件:表示总的旅行时间(交通时间和景点逗留时间)
不超过给定时间10天;
@for(jingdian(i):@sum(jingdian(j):r(i,j))=@sum(jingdian(j):r(j,i)));
@for(jingdian(i)|i#eq#1:@sum(jingdian(j):r(i,j))=1);
```

```
@for(jingdian(i)|i#ne#1:@sum(jingdian(j):r(i,j))<1);!这三个约束条件:表示起点(成都)有且仅有一条路线出去和一条路线进来，其它景点要么有且仅有一条路线出去和一条路线进来，要么既没有路线出去也没有路线进来;
@for(links:@bin(r));!约束条件:表示0-1变量约束;
@sum(jingdian(j):@sum(jingdian(i):r(i,j)))=n;!约束条件:表示旅游景点的数目为n的约束;
@for(jingdian(i):@for(jingdian(j)|j#gt#1#and#j#ne#i:l(j)>=l(i)+r(i,j)-(n-2)*(1-r(i,j))+(n-3)*r(j,i)));
@for(jingdian(i)|i#gt#1:l(i)<n-1-(n-2)*r(1,i);l(i)>1+(n-2)*r(i,1));!这两个约束条件：为了控制不出现两个以上环形回路，保证有且仅有一条环形路线;
```