Establishment and Solution of Airport Taxi Passenger Transport and Revenue Model Based on Grey Correlation Degree

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Abstract: With the rapid development of the tourism and transportation industry, urban residents are becoming more and more convenient to travel, and the public's attention to the issue of airport taxi passenger and revenue is also increasing. This article will build a selection decision model, a ride efficiency index model, and taxi mileage revenue model, which studies taxi driver decision-making, airport taxi riding efficiency, and balanced revenue. In the first question, nine indicators are selected based on certain principles as the influencing factors in selecting a decision model; secondly, it is obtained by the analytic hierarchy process. Get the weight to form the column vector ω; then use the gray correlation analysis method to calculate the correlation degree of each indicator by substituting the weight column vector ω to get the ranking of the degree of influence of each indicator on the decision result. The model solution will be implemented in the second problem. In the second question, the relevant data of different time periods in Shanghai Pudong International Airport were collected and applied to the problem one model. Finally, it was concluded that the best overall benefit for taxi drivers to choose to carry passengers at 18:00 that day.

1. Introduction

With the continuous development of China's economy, the level of residents' consumption has gradually increased, and more and more people choose to travel by air [1]. The roadside taxi transport system at the hub airport is one of the important transportation links between the airport and the city. Whether the operation is smooth, the planning is reasonable, and the public experience all reflect the level of public transportation management in a city [2]. However, there are often passenger queues and taxis in the airport to carry passengers, which makes taxi drivers how to choose between queuing to carry passengers and returning to the city, and how to manage taxis at the airport. Reasonable passenger loading and taxi queuing have become a major problem for the airport.

2. Model Establishment And Solution

2.1 The First Question

2.1.1 Establishment of model one

(1) Sub-question one

For sub-problem one: Analyze and study the influencing mechanism of factors related to taxi driver decision-making. In this paper, we will use the gray correlation analysis method to calculate the gray correlation between various indicators, so as to obtain the degree of influence of each indicator on taxi driver decision-making. The comparison between them, thus explaining the mechanism of action between the various influencing factors. In order to simplify the calculation, this article chooses to calculate by spss 24.0 software. According to the gray system theory, if x= { x_0 , x_1 , x_2 ,... ..., x_m) is the gray correlation factor set, where x_0 is the reference data sequence, x_i (i = 1,2,……, m) is the comparison data series, x_0 (k) and x_i (k) are x_0 with x_i K-th data point. That is:

$$x_0 = (x_0(1), x_0(2), \ldots\ldots, x_0(n))$$

$$x_1 = (x_1(1), x_1(2), \ldots\ldots, x_1(n))$$

$$x_2 = (x_2(1), x_2(2), \ldots\ldots, x_2(n))$$

$$\ldots\ldots$$

$$x_m = (x_m(1), x_m(2), \ldots\ldots, x_m(n))$$

Otherwise:

$$\Delta_{0i}(k) = |x_0(k) - x_i(k)|$$

$$\Delta_{min} = \min_i \min_k \Delta_{0i}(k)$$

$$\Delta_{max} = \max_i \max_k \Delta_{0i}(k)$$

$$\mathrm{r}(x_0(k), x_i(k)) = \frac{\Delta_{min} + \rho\Delta_{max}}{\Delta_{0i}(k) + \rho\Delta_{max}}$$

$$\mathrm{r}(x_0, x_i) = \sum_{k=1}^{n} \omega_k r(x_0(k), x_i(k))$$

In general, if r (x_0, x_i)>r(x_0, x_j), then x_0 versus x_i relevance ratio x_0 versus x_j is more relevant, in other words x_i correct x_0 degree of influence x_j bigger.

(2) Sub-question two

Aiming at sub-problem two: comprehensively considering the changing rules of the number of passengers at the airport and the benefits of taxi drivers, a taxi driver selection decision model is established. First, the corresponding indicators need to be selected as influencing factors, both as application indicators of sub-problem one and at the same time in sub-problem two the weight setting is carried out in this paper. AHP analytic hierarchy process is used to determine the weight of each influencing factor, the weight matrix is constructed, and the weight calculation is performed by spss 24.0 software to obtain the weight value of the corresponding index. Finally, the choice of airport taxi driver is constructed. The decision index model is used as the basis for the driver's decision.

1) Index selection principle

The selection of indicators for selecting a decision model should meet the following principles:

a. Objectivity principle: The selected indicators should be able to objectively reflect the status of tuition fees in colleges and universities.

b. Quantifiable principle: The selected indicators should be quantifiable for quantitative analysis.

c. One-time principle: The selected indicators should be data that can be directly represented in the data without secondary calculation.

d. Principle of openness: The selected indicators should be publicly available in the literature, so that they can be collected and used for research.

2) Index selection results

According to the requirements of the topic, comprehensively considering the changing rules of the number of passengers at the airport and the income of taxi drivers, this article has carried out a hierarchical analysis on the selected indicators, and a total of 3 first-level indicators: the pool factor X_1 passenger factor X_2 operating factor X_3 9 secondary indicators: average number of taxis released x_1 average effective berth x_2 average waiting time x_3 flights x_4 nnumber of passengers x_5 average passenger per vehicle x_6 ,mileage x_7 ,fare x_8 , time cost x_9 the hierarchical relationship is shown in Table1.

a. ahp hierarchy analysis

First, a weight matrix must be constructed between all the first-level indicators and between the first-level and second-level indicators, and then substituted into the spss 24.0 software to perform the AHP hierarchy analysis to obtain the weight of each indicator.

b. Choosing a decision model index score

From the results of the above indicator weight analysis, the weight value of each of the 9 secondary indicators can be calculated ω_k (k = 1, 2,…… 9). The weights obtained can not only be substituted into the sub-problem one to calculate the grey correlation between the indicators, but also can be used as the weight vector of this problem for the establishment of the taxi driver selection decision model Here you get the combined weight vector:

$$\omega = (\omega_1 \quad \omega_2 \quad \omega_3 \quad \omega_4 \quad \omega_5 \quad \omega_6 \quad \omega_7 \quad \omega_8 \quad \omega_9)^T$$

After getting relevant data, a decision matrix will be formed:

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{81} & x_{82} & \cdots & \cdots & x_{8n} \\ x_{91} & x_{92} & \cdots & \cdots & x_{9n} \end{pmatrix}$$

Record total score $Y = \omega X = \sum_{k=1}^{9}\sum_{i=1}^{n}\omega_k x_{ki}$ Calculate the score of each group of programs. The group with the highest total score is the best choice for decision making. The total score obtained Φ That is, the score index for the taxi driver selection decision model constructed can be used as the basis for driver selection decisions.

Table 1. Hierarchical relationship of each indicator

Choice Decision Model x	Car pool factor X_1	Number of taxis released x_1
		Effective berth x_2
		Average waiting time x_3
	Passenger factor X_2	Flights x_4
		Number of passengers x_5
		Average number of passengers per vehicle x_6
	Operational factor X_3	mileage x_7
		fare x_8
		time cost x_9

2.2 Second Question

2.2.1 Data collection and preprocessing

Table 2. Relevant index data of Shanghai Pudong International Airport in each time period

time	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
15:00	355	1.31	10.39	36	3309	7.4	53	186	60
16:00	571	1.07	12.95	36	3417	6.9	47.9	168	55
17:00	708	1.03	16.71	27	2077	5.1	52.8	186	65
18:00	575	1.37	14.27	33	3948	7.3	53.9	192	72
19:00	487	2.01	13.82	26	1831	8.2	56.3	201	80
20:00	534	1.73	11.05	37	4595	10.7	53.6	189	72
21:00	415	1.53	9.21	36	4680	11.3	47.9	169	62
22:00	737	1.05	7.47	32	2077	8.6	41.6	146	55

23:00	761	1.02	8.29	26	1745	6.5	40.9	143	50

Taking Shanghai Pudong International Airport as the object, data at different time periods in a day were randomly selected for collection and preprocessing. The statistical indicators were selected 9 secondary indicators: the average number of taxis released x_1 average effective berth x_2 average waiting time x_3 flights x_4 nnumber of passengers x_5 average passenger per vehicle x_6, mileage x_7, fare x_8, time cost x_9. Specific indicator values such astable. As there is no taxi flow from Pudong Airport from 3am to 4 am on the same day, the data in the above two time periods in the original data are deleted as invalid data, and the following data are valid data after screening.

2.2.2 Correlation between indicators

(1) Solution of grey correlation

First, the data sequence matrix A is dimensionless. In order to reduce the calculation, this paper uses the database intrinsic function B = zscore (A) in MATLAB 2017a software to directly obtain the dimensionless matrix B. FigureShown:

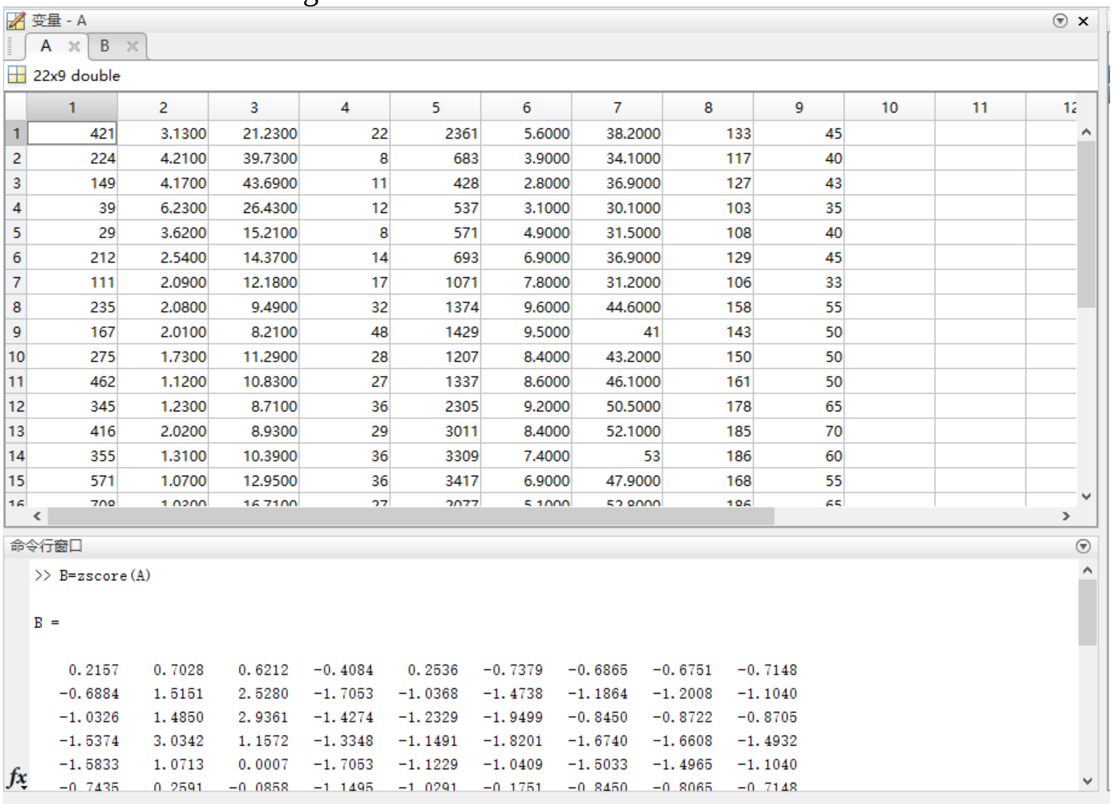


Figure 1. Matlab dimensionless processing

Then substitute the dimensionless matrix into the correlation coefficient:

$$r(x_0(k), x_i(k)) = \frac{\Delta_{\min} + \rho\Delta_{\max}}{\Delta_{0i}(k) + \rho\Delta_{\max}} (\rho = 0.5)$$

The correlation coefficient matrix with the time series as the reference sequence is obtained, and the obtained gray correlation coefficient matrix is substituted into the correlation degree formula to obtain the correlation degree of each index. As table shown:

Table 3. Gray correlation results

	Relevance results	
Evaluation item	Correlation	Ranking
x_1	0.730	1
x_2	0.531	9
x_3	0.582	5
x_4	0.582	5
x_5	0.580	7
x_6	0.580	7
x_7	0.589	4
x_8	0.701	2
x_9	0.687	3

(2) Conclusion of relevance

By observing the above correlations, we can know the degree of influence of various indicators on the taxi driver's decision-making scheme. Among the nine selected indicators, the most significant influence on the taxi driver's decision-making is the average number of taxis released. x_1 Followed by taxi fare x_8 , the degree of correlation is higher than 0.7, which shows that the degree of influence is very large. x_9 ,mileage x_7 average waiting time x_3 flights x_4 Number of passengers x_5 and average passengers per vehicle x_6 the correlation degree of these six items is between 0.58 and 0.59, which shows that the impact is greater. The last ranking of the correlation degree is the average effective berth. x_2 The correlation degree is only 0.531, which has the least impact on driver decisions.

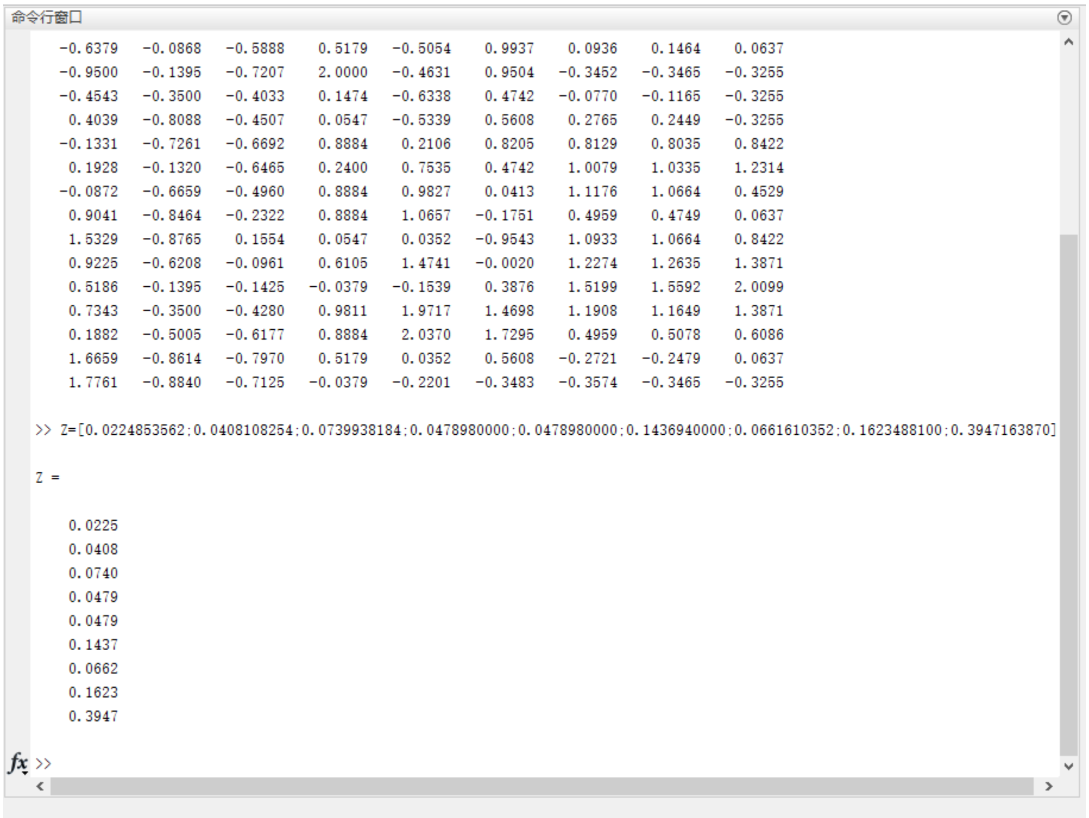
2.2.3 Selection decision model solving

(1) Index value of decision model

According to the principle of the AHP analytic hierarchy model, it is necessary to calculate the product of the decision matrix and the weight vector to obtain the total score value of each scheme and compare it to the maximum value. The decision matrix is the data matrix obtained through the dimensionless processing above,

$Y = \omega X = \sum_{k=1}^{9}\sum_{i=1}^{22}\omega_k x_{ki}$, count score matrix.

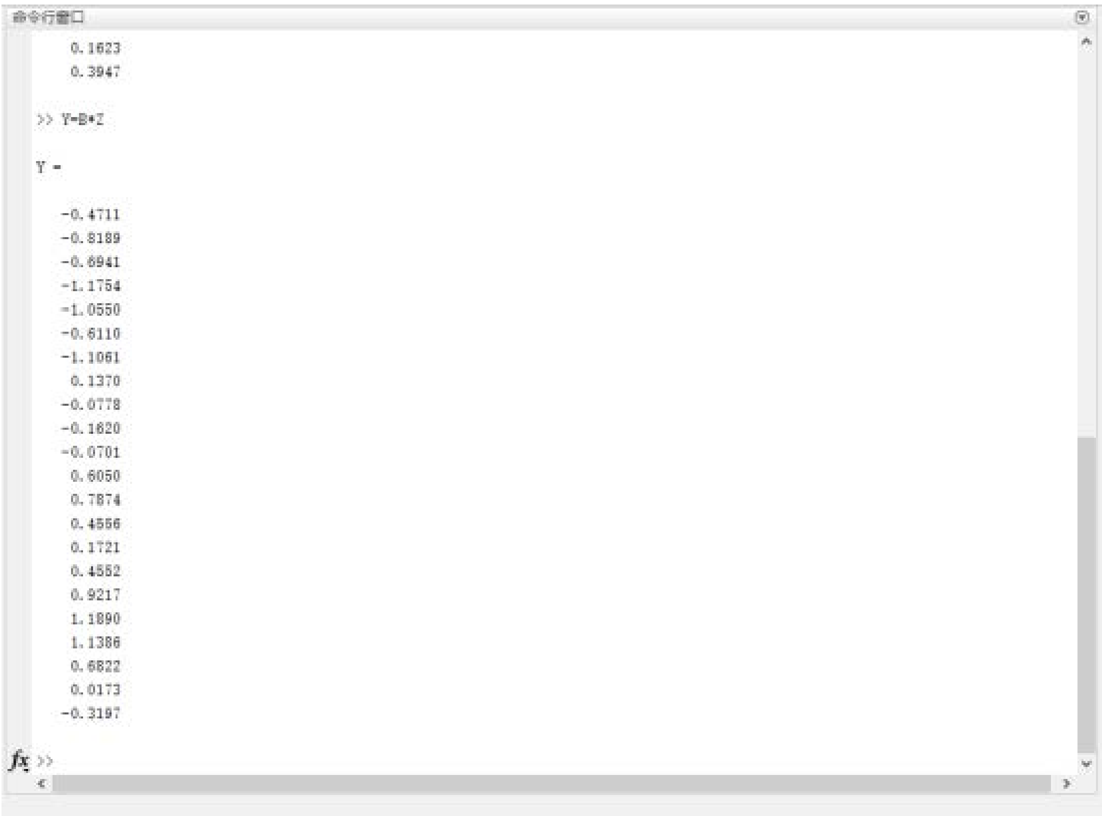
This article defines the same scheme as different time periods within a day, and because the invalid data from 3 am to 4 am is deleted from the original data, 22 schemes can be finally obtained, so n = 22, each scheme represents the time In order to reduce the amount of calculation, MATLAB 2017a software is used again to combine the weights of problem one to generate a weight matrix Z = ω = $(\omega_1 \quad \omega_2 \quad \omega_3 \quad \omega_4 \quad \omega_5 \quad \omega_6 \quad \omega_7 \quad \omega_8 \quad \omega_9)^T$, as shown in Figure 2:



```
命令行窗口
  -0.6379  -0.0868  -0.5888   0.5179  -0.5054   0.9937   0.0936   0.1464   0.0637
  -0.9500  -0.1395  -0.7207   2.0000  -0.4631   0.9504  -0.3452  -0.3465  -0.3255
  -0.4543  -0.3500  -0.4033   0.1474  -0.6338   0.4742  -0.0770  -0.1165  -0.3255
   0.4039  -0.8088  -0.4507   0.0547  -0.5339   0.5608   0.2765   0.2449  -0.3255
  -0.1331  -0.7261  -0.6692   0.8884   0.2106   0.8205   0.8129   0.8035   0.8422
   0.1928  -0.1320  -0.6465   0.2400   0.7535   0.4742   1.0079   1.0335   1.2314
  -0.0872  -0.6659  -0.4960   0.8884   0.9827   0.0413   1.1176   1.0664   0.4529
   0.9041  -0.8464  -0.2322   0.8884   1.0657  -0.1751   0.4959   0.4749   0.0637
   1.5329  -0.8765   0.1554   0.0547   0.0352  -0.9543   1.0933   1.0664   0.8422
   0.9225  -0.6208  -0.0961   0.6105   1.4741  -0.0020   1.2274   1.2635   1.3871
   0.5186  -0.1395  -0.1425  -0.0379  -0.1539   0.3876   1.5199   1.5592   2.0099
   0.7343  -0.3500  -0.4280   0.9811   1.9717   1.4698   1.1908   1.1649   1.3871
   0.1882  -0.5005  -0.6177   0.8884   2.0370   1.7295   0.4959   0.5078   0.6086
   1.6659  -0.8614  -0.7970   0.5179   0.0352   0.5608  -0.2721  -0.2479   0.0637
   1.7761  -0.8840  -0.7125  -0.0379  -0.2201  -0.3483  -0.3574  -0.3465  -0.3255

>> Z=[0.0224853562;0.0408108254;0.0739938184;0.0478980000;0.0478980000;0.1436940000;0.0661610352;0.1623488100;0.3947163870]

Z =

    0.0225
    0.0408
    0.0740
    0.0479
    0.0479
    0.1437
    0.0662
    0.1623
    0.3947

fx >>
```

Figure 2. Matlab weight matrix input

Then multiply the weight matrix z by the dimensionless matrix b: $Y_{22\times1} = B_{22\times9} \times Z_{9\times1}$, That is, a column vector composed of the respective index score values of the 22 schemes, as shown in Figure3:



```
命令行窗口
    0.1623
    0.3947

>> Y=B*Z

Y =

   -0.4711
   -0.8189
   -0.6941
   -1.1754
   -1.0550
   -0.6110
   -1.1061
    0.1370
   -0.0778
   -0.1620
   -0.0701
    0.6050
    0.7874
    0.4556
    0.1721
    0.4552
    0.9217
    1.1890
    1.1386
    0.6822
    0.0173
   -0.3197

fx >>
```

Figure 3. Matlab matrix multiplication

Then we got the index score column vector of 22 schemes, and got the index score of each scheme:

$Y_1 = -0.4711$ $Y_2 = -0.8189$ $Y_3 = -0.6941$ $Y_4 = -1.1754$ $Y_5 = -1.0550$ $Y_6 = -0.6110$

$Y_7 = -1.1061$ $Y_8 = 0.1370$ $Y_9 = -0.07a78$ $Y_{10} = -0.1620$ $Y_{11} = -0.0701$ $Y_{12} = 0.6050$

$Y_{13} = 0.7874$ $Y_{14} = 0.4556$ $Y_{15} = 0.1721$ $Y_{16} = 0.4552$ $Y_{17} = 0.9217$ $Y_{18} = 1.1890$

$Y_{19} = 1.1386$ $Y_{20} = 0.6822$ $Y_{21} = 0.0173$ $Y_{22} = -0.3197$

3. Conclusion

According to the score value obtained by MATLAB 2017a software, the optimal scheme can be obtained by comparing the score values of 22 schemes. The definition scheme is a_n (n = 1, 2,……, 22), the best solution is a*, which can be obtained from the above results:

$$Y(a^*) = \max_{1 \le n \le 22} Y(a_n) = Y(a_{18}) = 1.1890$$

The best plan obtained from this is the 18th data series plan, that is, the taxi driver chooses to leave the bus at 18:00 on the same day for the best overall benefit.

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