Determination of the Waiting Plan of Airport Taxi Driver Based on Decision Model

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Abstract

Taxis are the main means of transportation between the city and the airport, and the taxi drivers who arrive at the airport will face the problem of decision choice in the process of going to the arrival area and waiting for passengers to return to the city or directly returning to the city without taking passengers.In order for the driver to make a reasonable decision, for the choise to stay at the airport waiting to take passengers, this paper takes taxi as the customer and applies the queuing service model. Based on the main cause, this paper analyzes the influence of the change in the number of flights and the number of vehicles in the storage pool on the waiting time cost. At the same time, for the taxi directly returning to the urban area, the cost model is determined based on the no-load fuel charge and the potential loss of passengers, and a selection decision model is established. The two choices are quantified as cost loss, and the driver's choice is determined by comparing the cost loss of the two choices.

Keywords

Queuing theory, Principal Component Analysis, Cost decision model.

1. Introduction

With the rapid development of economy, the geographical location of the airport is far away from the downtown area. This has promoted the development of the taxi industry around the airport and improved the taxi drivers' income from carrying passengers. At the same time, the decision-making problem of how taxi drivers choose to carry passengers has also emerged. Taxi drivers who pick up passengers at the airport can either go to the airport to wait for them or return to the city without taking them. By knowing the number of flights arriving at the airport in a certain period of time and the number of vehicles in the "car storage pool", taxi drivers can make a reasonable decision, which can effectively reduce unnecessary time costs and losses and increase overall profits. In order to help taxi drivers to make reasonable decisions, this paper comprehensively discusses the influencing factors of taxi drivers' decisions based on the analysis of the main causes, takes into account the changing rules of the number of passengers in the airport and the benefits of taxi drivers, establishes the taxi drivers' fee decision-making model, and gives the selection strategies.

2. Model

2.1 Analysis

To get the driver's choice decision-making model, this paper establishes cost model of two kinds of different situation. In the first plan, to stay in the airport waiting for the taxi, using queuing theory model, considering the flight number and "car pool" of the existing vehicle storage, computing the taxi waiting time, and get "taxi passengers waiting time cost model". The second plan, for empty return soliciting urban taxi directly, according to the light fuel and the potential gains and losses "directly back to the cost of the taxi model" is established. Finally, compare the two choice,make decision.

2.2 Assumption

In the analysis of this paper, it is assumed that 20% of the passengers arriving at the airport will choose to take a taxi, and one person will take a taxi.The driver's mileage between the airport and the city is fixed.

2.3 The cost model of waiting at the airport

2.3.1 Influence factors

After seeing off passengers to the airport, the driver enters the car pool to wait for them or returns to the city center. Variables that can be used as a reference for the driver's decision are: the number of flights arriving at this stage **a**, and the number of vehicles in the "storage pool" **b**. The two options correspond to two different waiting costs: "airport waiting time cost" and "the sum of the no-load cost of returning to the downtown area and the potential benefits of carrying passengers". By establishing a queuing service system model to solve the waiting costs of the two options and comparing them, the driver's selection strategy can be obtained.

2.3.2 Model Establishment

(1) Taxi waiting time calculation

According to the actual situation, the airport flights arrived in batches, but each time the number of passengers arrived is large. Therefore, we assume that there are passengers waiting to be taken in the airport bus area at all times, and we can get the number of flights (passengers) per unit time period. The theory of queuing is introduced, in which passengers serve as the "service platform" and taxis waiting to pick up passengers serve as the "customers" in the service system. For the convenience of calculation, the model can be approximated as [M/M/1] type queue[1]:

①Input process: the taxi source is unlimited, the taxi enters the storage pool one by one, and the arrival flow follows the poisson distribution.

②Queuing rules: taxis are put in the same queue, first come, first served (FCFS).

③Service organization: there is only one "service platform", and the duration of each taxi "receiving service" is subject to a negative exponential distribution.

The system has two input parameters：

λ : Customer arrival rate: the number of customers per unit time system.

μ : Service rate: the number of customers who complete the service in unit time.

(2) solving method

① $p_n = P\{N=n\} \quad (n=1,2,\ldots)$ is the probability distribution that the taxi "customer" is n after the system reaches the equilibrium state:

$$p_0 = \frac{1}{1+\sum_{n=1}^{\infty}\rho^n} = \left(\sum_{n=0}^{\infty}\rho^n\right)^{-1} = \left(\frac{1}{1-\rho}\right)^{-1} = 1-\rho \tag{1}$$

since[M/M/1] queuing system is a typical birth and death process, so $p_n = \rho^n p_0, \quad n=1,2,\ldots$,

$$p_n = (1-\rho)\rho^n \qquad n = 1, 2, \ldots \tag{2}$$

ρ is the intensity of the service， $\rho = \lambda/\mu$. ρ reflects how busy the system is, when $\rho<1$ can get p_n . Therefore, in order for the system to reach a statistical equilibrium state, the condition for solving the queuing problem based on the analytical method is $\rho<1$,

②[M/M/1] The service time of the "customer" taxi in the queuing system is subject to an exponential distribution, as follows:

The average length of stay of "customers" is:

$$W_s = \frac{1}{\mu - \lambda} \tag{3}$$

③According to [2], The average boarding time for each group was 56s, so $\mu = \frac{1}{56}$车/s

The daily number of airport taxis Y is related to the daily number of flights arriving at the airport x1, the total number of taxis in the corresponding city, x2, and the airport size x3 (covering an area of square kilometers). According to the data of Y and x1, x2 and x3 in each city, the main cause analysis model is used. Is the average arrival rate of airport taxis per unit time $\lambda = \frac{Y}{T}$, So by analyzing the relationship between Y and x_i, you can get regression functions λ with respect to x1, x2 and x3.

Note: T is the number of time periods divided, I = 1,2,3.

Tabel. Relevant data of four major cities' airports

City	Airport	X1	X2	X3	Y
Beijing	Beijing Capital Airport	1200	66648	16410.54	20000
Shanghai	Shanghai Pudong International Airport	1080	48900	6340	11200
Hangzhou	Hangzhou Xiaoshan Airport	800	9910	559.2	6800
Chengdu	Chengdu Airport	1000	17587	14335	9300

(1. Standard deviation standardization of original data

(2. Calculate the correlation coefficient matrix R

(3. Solve all the eigenvalues and eigenvectors of R according to the jacobian method, and obtain the eigenmatrix

(4. The eigenvalues are arranged from small to large

(5. Column each feature root feature vector

(6. Calculate the principal component load

	x1	x2	x3
x1	1	0.923586225	0.791440492
x2	0.923586225	1	0.538787014
x3	0.791440492	0.538787014	1

Z1	83.77766158
Z2	15.71640084
Z3	0.505937583

λ1	λ2	λ3
2.513329847	0.471492025	0.015178127

Figure1. The calculation process

And we end up with the regression equation λ

$$y = 13.1818 \times x1 + 0.9683 \times x2 + 0.1263 \times x3 - 6272.4959 \tag{4}$$

(3) Taxi waiting time cost:

$$SA = b \times Ws \times e \tag{5}$$

Revenue from carrying passengers per unit time :

$$e = \text{Unit mileage taxi fare(yuan/Km)} \times \text{bill(Km/h)} \tag{6}$$

2.4 The Cost Model for the taxi go straight back

2.4.1 Analysis

For empty return to urban taxi directly, the cost of light fuel expenses and losses and the sum of the potential customer revenue sum up the total cost. Therefore, this paper obtains the equation of return taxi cost by collecting the required mileage from the city airport to the city, the fuel consumption per kilometer of the taxi, the oil price, the taxi passenger carrying standard, etc., and establishes the "direct return taxi cost model".

2.4.2 Model Establishment

(1) Determined parameters:

The average mileage S between the city and the airport, the oil price c , the taxi fare d per kilometer, and the known average fuel consumption Qs per kilometer = 0.08l/KM;

(2) The cost equation：

$$SB = s(c \times Q_s + d) \tag{7}$$

2.5 The establishment of cost decision model[3] for decision making

2.5.1 Analysis

After the cost models of the two choices are obtained, the cost equation is compared to determine the choice decision of the taxi driver.

2.5.2 Model Establishment

$$\Delta S = SA - SB \tag{8}$$

3. Result

$$\begin{cases} \text{When}\Delta S < 0\text{，SA has a lower time cost and chooses to stay in the airport and go to the arrival area to pick up passengers.} \\ \text{When}\Delta S \geq 0\text{，SB has a lower time cost and chooses to return to the city directly.} \end{cases}$$

4. Conclusion

In order to help taxi drivers make a better decision on whether to stay at the airport and wait for passengers, this paper, based on the classic queuing theory model, calculates the impact of airport related factors on the waiting time cost by using the principal cause analysis method for the choice of staying at the airport and waiting for passengers. In view of the choice of going directly back to the city for soliciting passengers, the loss cost is calculated based on the fuel consumption cost and the potential passenger cost of the loss, and then the cost decision model is established to solve the taxi driver's choosing problem by comparing the cost of the two choices.

References

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