Pick-Up Strategy of Airport Taxi Drivers Based on Queuing Theory Model

Zihan Wang
College of Maths, Hangzhou Normal University, Hangzhou 311121, China.

Abstract: In this paper, the dynamic programming of the airport taxi driver's picking up strategy is studied, through the modeling of the influencing factors, combined with the actual situation, the airport "pick up point" and "priority" arrangement strategy is given, and the algorithm is verified. For taxi driver selection strategy, we analyzed the related factors influencing the taxi driver decision-making mechanism, the influence of the possible influencing factors into consideration, and correlation analysis to determine the main factors and influence mechanism, and combining with the change rule of airport passenger Numbers and taxi driver returns, using the method of queuing theory, the taxi driver selection decision-making model is established, Thus, the driver's choice strategy is given. For an airport taxi driver selection scheme analysis, we choose Hangzhou Xiaoshan airport as an example, passengers take a taxi from Xiaoshan airport Avenue in Hangzhou city. Using the decision method of model 1, the choice of taxi driver in Xiaoshan airport is given. The authenticity of the model and its dependence on related factors are analyzed. Finally, we use the simulation data to verify the practicability of the model and the effectiveness of the algorithm, and solve the problem of picking up taxi drivers at the airport, so as to improve the efficiency of passenger traffic and the revenue of taxi drivers, and maximize the use of resources.
Keywords: Queuing Theory; Optimization Model

1. Problem analysis

Regarding the question of "airport taxi driver pick-up strategy", we analyzed the overall situation of the problem as follows.

In order to analyze the related factors influencing the taxi driver decision, the influence mechanism, we need to first possible influencing factors into consideration, and correlation analysis to determine the main factors and influence mechanism, and combining with the change rule of airport passenger Numbers and taxi driver returns, using the method of queuing theory, the taxi driver selection decision-making model is established, So the driver's choice strategy is given.

2. The establishment, solution and analysis of the model

In order to help airport taxi drivers make the picking strategy after seeing off passengers, we establish a taxi driver selection strategy model based on queuing theory. For the two choices of going to the arrival area to queue up and waiting for passengers to return to the urban area or directly emptying out to return to the urban area to attract passengers, we set up a mathematical model from the starting point of time cost and driver's income, combined with the relevant knowledge of queuing theory, to help drivers make customer picking decisions according to different situations.

2.1 Analysis of factors affecting taxi drivers' decision making

First of all, we need to study the factors that may affect drivers' decision-making from both theoretical and practical aspects, and find out the factors with greater influence through correlation analysis. Then, we can obtain the influencing mechanism of different factors through data processing.

Factors that may affect the driver decision has the absolute objective factors and random factors, among them, time, weather, seasons, and so on natural factors and geographical factors such as the distance from the airport to downtown is objective, the number of the taxi car storage in the pool and the demand of taxi factors associated with the choice of all drivers and passengers, belong to the random factors.

Then we classify these factors. The factors that affect the driver's decision are mainly time and revenue. All the factors that affect the decision can be divided into three categories, namely, queuing time, return time and revenue.

2.2 Correlation analysis

In the study of the relationship between the number of taxis and the number of flights, it is necessary to conduct correlation analysis through Pearson correlation coefficient to find out the indicators related to the experimental dependent variable, and then conduct fitting regression to study the relationship between various indicators and the dependent variable.

Pearson correlation coefficient calculation formula:

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N})(\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

Correlation analysis showed that R value was 0.8673, indicating a significant linear relationship.

Based ON THE correlation analysis OF ALL possible factors, the main factors affecting the decision of taxi drivers are: the number of taxis in line, the number of passengers getting off the plane at the airport, the time needed from the airport to the city, and the number of flights.

2.3 Queueing theory model construction analysis

The factors that affect the decision of taxi drivers include: the number of taxis in line, the number of passengers getting off the plane at the airport, the time needed to get from the airport to the city, the number of flights, etc. With the goal of taxi drivers' income, the number of passengers getting off the plane and the number of taxis queuing are analyzed and compared, which can be discussed in two cases:

The first case, the number of passengers is greater than the line up the taxi number, the number of passengers, queuing for taxis, bus zone average time for a taxi passenger left, the average distance to the airport to downtown, the taxi fare for, more than start distance, each one kilometer costs increase, driving a taxi one kilometer to spend time, The gas cost for a taxi to travel one kilometer is.

Then the relationship between the taxi fare and the distance is:

$$W = \begin{cases} w_0, S \le S_0 \\ w_0 + w(S - S_0), S > S_0 \end{cases}$$

If the driver chooses plan A and waits in line to pick up passengers, the waiting time is and the time to take passengers back to the city is, then the driver's income in the time is

$$Q_1 = W - \overline{S}L$$

If the driver chooses plan B, he returns to the city to pick up passengers. For the number of passengers received by the driver in the urban area, within a certain time interval, the probability of the driver receiving a single passenger is only related to the length of time, which is stable. The probability of receiving a single passenger in the time period has nothing to do with the previous passengers and has no aftereffect. Only one passenger is received at a time, which is common. The number of passengers received by the driver in the urban area satisfies the stability, no aftereffect and universality. It can be seen that the probability of the driver receiving a single passenger in the time follows the Poisson distribution, namely:

$$P_k(t) = e^{-\lambda t}\frac{(\lambda t)^k}{k!}, (k = 0,1,2,\cdots)$$

Where, λdenotes the average number of passengers received per unit time. When Δt sufficient, the probability of not receiving a passenger within the time is $P_0(\Delta t) = e^{-\lambda t} \approx 1 - \lambda\Delta t$

If the average price of carrying passengers in the urban area is $\overline{w}$, the revenue of the driver in the time $\mathrm{xM} + \overline{\mathrm{S}}\mathrm{t}_0$ is

$$Q_2 = k_1\overline{w} - k_1\overline{S}L$$

Where, $k_1$is the driver in the time xM, with probability to estimate the driver may receive the number of passengers.

For the first case, $Q_1 \geq Q_2$, at that time, the driver queued up to wait, when$Q_1 < Q_2$, empty return

In the second case, the number of passengers is smaller than the number of taxis in the queue.

If drivers choose plan A, waiting for service, to the number of passengers who arrive at the airport, choose taxi ratio is μ, the case of A period of time I all flights for the amount of the shipping space, the average load factors is, for the driver waiting for the first batch of flight time, at that time$\mathrm{K}_0 + \sum \alpha R_i\mu \geq M + 1$, the driver received A passenger, waiting time $\sum T_i$, time to take passengers to the city is $\overline{S}t_0$, the income of the driver in time $\overline{S}t_0 + \sum T_i$:

$$Q_3 = W - \overline{S}L$$

If the driver chooses plan B and directly returns to the urban area to pick up passengers, similar to Plan B in the first situation, the income in the period $\overline{S}t_0 + \sum T_i$ is

$$Q_4 = k_2\overline{w} - k_2\overline{S}L$$

Where, is the estimated number of passengers a driver may receive with 90% probability under time $\sum T_i$.

For the first case, at that time $Q_3 \geq Q_4$, the driver queued up to wait, when $Q_3 < Q_4$, empty return.

2.4 Analysis of decision model results

Based on the discussion of the above two cases, we make choices for drivers in different situations:

K ≥ M

Feasible solution	Time	Earnings	Decision making
Passenger returns	$\mathrm{xM} + \overline{\mathrm{S}}\mathrm{t}_0$	$Q_1 = W - \overline{S}L$	At that time $Q_1 \geq Q_2$, waiting in line At that time $Q_1 < Q_2$, empty return
Empty return		$Q_2 = k_1\overline{w} - k_1\overline{S}L$	

K < M

Feasible solution	Time	Earnings	Decision making
Passenger returns	$\overline{S}t_0 + \sum T_i$	$Q_3 = W - \overline{S}L$	At that time $Q_3 \geq Q_4$, waiting in line At that time $Q_3 < Q_4$, empty return
Empty return		$Q_4 = k_2\overline{w} - k_2\overline{S}L$	

3. Model innovation and promotion

The optimization model has scientific and accurate characteristics in dealing with transportation, assignment and other problems. It can solve the most consistent understanding with the objective conditions, and quantitatively describe the logical relations, sequential relations and mutually exclusive constraints among discrete variables reflected by phenomena such as open and close, take and discard, and have and have not. Therefore, the optimization model is very suitable for describing and solving many problems that people care about, such as circuit design, factory location, production planning, travel and shopping.

Multi-objective model can solve the best solution of the problem driven by different objectives, and has the characteristics of simple calculation and high accuracy in dealing with multi-objective optimization problems. It has the significance of popularization and reference, such as solving the comprehensive utilization of river water resources, irrigation, power generation, flood control and other problems.

References

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