Taxi Problem at Airport

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***Abstract*—This paper mainly analyses whether airport taxi drivers enter the "car storage pool" to wait for passengers or return empty to make decisions when they deliver passengers to the airport. A model is established to determine the factors affecting the waiting time of taxi t and the weight of the influence on t. Model 1 uses the model of entropy weighting method. Firstly, the data are processed in dimensionless way and eliminated twice, respectively, based on the feasibility of the decision-making indicators and based on the correlation of the evaluation indicators. Finally, the main factors affecting the waiting time of airport drivers are: the number of airport "car pool" cars, weather conditions, holidays, time factors, arrival flights, which correspond to each other. The weights of the indicators are 0.0906, 0.0579, 0.0455, 0.0559, 0.0652. Combining the formula and the actual data, the waiting time of the driver can be calculated. Then the final decision-making scheme is given by comparing the driver's income. Given the formula Qi (waiting for passengers to return), Qj (no-load return), taxi fare standard and driver's average monthly salary and average daily working time, we can get the Qx difference between the two decision-making modes. Through the positive and negative of Qx difference, we can judge the advantages and disadvantages of the two decision-making models and make reasonable decisions. Because the problem of taxi queuing for passengers and passenger queuing for boarding is relatively common, and the airport opens two-way channels for related allocation. Therefore, in order to solve this problem, we use genetic algorithm-based scheduling model to construct the genomic relationship between different passengers and different taxis, and bring data into the calculation to simulate how to arrange boarding points, passengers and taxis, so as to maximize the efficiency of riding.**

Keywords—Entropy Weight Method, Genetic Algorithms, Queuing Theory, Gravity Coefficient Prediction Model.

I. Restatement of the Problem

A. Introduction

This year, with the development of science and technology, traffic travel has become more and more fast and convenient. Flying travel has become more and more popular in society, but the problems that follow have become more and more complex. For passengers, airport taxi passenger is a highly concerned issue, whether it is the current number of passengers, the number of taxis available, the number of flights arriving in the current time and the current weather and other issues directly affect the taxi driver's income. For passengers, their concern is whether they can get a taxi after leaving the airport, while for taxi drivers, they often care more. Passengers entering the airport need to queue in the storage pool, and some taxis will lose money because of the short driving distance. Therefore, some special arrangements should be made for the short-distance taxis, through reasonable allocation, to reduce the loss caused by the waiting time process and the short passenger-carrying distance. When they enter the storage tank waiting to avoid no-load situation or accidents caused by emergencies should also be considered by establishing corresponding models.

B. Question

(1) Analyze the relevant factors affecting taxi driver's decision-making, considering the changing rule of airport passenger number and taxi driver's income comprehensively, establishing the decision-making model of taxi driver's choice, and giving the driver's choice strategy.

(2) Airport taxi revenue is related to the mileage of passengers. The destination of passengers is sometimes far and sometimes near. Taxi drivers can not choose passengers and refuse to carry passengers. However, taxis are allowed to carry passengers back and forth many times. The management intends to give certain "priority" to some taxis that return short-distance passengers, so as to make the revenue of these taxis as balanced as possible, and try to give a feasible "priority" arrangement scheme.

II. Problem Analysis

A. Question One

Problem one is mainly about data analysis, processing and evaluation model planning. Firstly, in order to fully consider the number of airport passengers and passenger revenue in problem one, we need to take the waiting time t of drivers as an intermediate variable, and then we can get the solution of the waiting time t of drivers by weighting the factors affecting the intermediate variable through the method of entropy weight. Then establish the output of model two pairs of model one. Considering the distance and time cost, the two decision models are judged and the appropriate model is selected.

B. Question Two

Our goal is to provide passenger priority for short-haul taxis when they re-enter the airport, and to arrange for long-distance passenger transport as much as possible. There are many optimization objectives, so we can establish queuing theory model and gravity coefficient prediction model, combine passenger arrival rate and taxi satisfaction rate, and get the best solution through computer analysis to balance the final income of short-distance passenger taxi drivers.

III. Model Hypothesis

(1) Assume that the data obtained are authentic and representative, some abnormal data are neglected.

(2) Assume that the probability of all events occurring is the same for each driver

(3) Assume that all taxi drivers have the same driving ability, belonging to the medium level.

(4) Assume that the main factors are independent of each other and will not affect each other.

IV. SYMBOLIC DESCRIPTION

TABLE 1 SYMBOLIC DESCRIPTION.

Symbol	Explanation
Qi	Volume i Taxi Revenue Index
X_{ij}	Item j Index Data of Taxi i
P_{ij}	The Ratio of Standardized Data in Item j of Taxi Item i
E_j	Information Entropy of Index j
W_j	Weight of index j
k	Number of screened indicators
t_i	Waiting time of taxi i

V. ESTABLISHMENT AND SOLUTION OF PROBLEM TWO MODEL

A. Taxi Driver Selection Decision Model

Considering the complexity of taxi driver's decision-making model, the relative objectivity and the limitations of data sets and quantification, this paper adopts the relative subjectivity, which can make full use of the entropy method of data characteristics to empower the indexes of T in the decision-making system, and then calculates the waiting time of taxi at the airport according to the weight ratio. The greater the value of the index, the greater the time cost of the taxi.

Computation of standardized data xij specific gravity Pij:

$$P_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} \tag{1}$$

The calculation of information entropy E_i of each index:

$$E_i = -\ln(n)^{-1} \sum_{j=1}^{n} P_{ij} \ln P_{ij} \tag{2}$$

The calculation of the weight of each index:

$$W_i = \frac{1-E_i}{i = \sum_{i=1}^{k} 1-E_i} \tag{3}$$

B. Removal of Evaluation Indicators Based on Relevance

Considering that there are more or less links between multiple indicators in the same domain, if the two indicators are highly correlated, the impact on taxi drivers'choice of decision-making model will overlap, which virtually strengthens the effect of the impact on the target layer.

In this paper, Pearson correlation coefficients are calculated for the data of multiple indicators in the same field level, and the correlation coefficients are analyzed. If the correlation coefficients are greater than 0.85, it is considered that there is a strong correlation between the two indicators. The correlation coefficient between weather conditions and seasonal factors is more than 0.85, as shown in Table 2 below.

From Table 2, it can be seen that the correlation coefficient between "weather condition" and "seasonal factors" is 0.87, which has a strong correlation. However, the correlation coefficient between other indicators is less than 0.85, so it can be considered that the correlation between other indicators is weak. Weather conditions themselves are subdivisions of each seasonal period, so the index of "seasonal factors" is chosen to be excluded.

TABLE 3. WEIGHTS OF INDICATORS (PART)

Index Level	Index Weight
Number of Airport "Storage Pool" Vehicles	0.906
Weather Condition	0.0579
Holiday and Vacations	0.0455
Time Factor	0.0559
Number of Arrival Flights	0.0652

According to the result analysis of the index weight, in the model of influencing taxi selection decision-making, the number of airport "car storage pool" and the number of arrival flights occupy the largest weight, and the greater the impact on taxi driver's decision-making. The weather conditions determine the operation of the airport, and the time factor for the night Airport (before dawn).The operation of Flight 10 does not change much compared with the daytime, but due to the intercity bus and subway linking the urban area will be out of service in the evening, so for taxi drivers, the evening passenger volume will also reach a certain peak. Therefore, the decision-making of taxi drivers will focus on discussing the change of passenger flow in one day operation of the airport.

C.Taxi Drivers' Decision-making Strategies

In the process of decision-making, it often needs to be judged from many aspects. Then we can use the input of the data weight value to simulate the data by Monte Carlo. We can see that the travel time, weather conditions, the number of taxis around the airport and the number of flights have a great impact on the waiting time of drivers at the airport. We can get the current demand by assigning the appropriate weight value. We have to wait for time and then we can make the optimal decision according to the comparison of income in two cases.

VI. ESTABLISHMENT AND SOLUTION OF PROBLEM TWO MODEL

A. Establishment and Analysis of Model

a. Analysis of the Model

Taxi passenger income is related to the mileage of the passenger. In order to balance the income of the taxi driver, it is necessary to give priority to the taxi with short-distance passengers. For taxi drivers, when the destination of the passenger is relatively short, there will be losses due to the relationship between the length of stay in the storage tank and the journey, so short distance drivers should arrange green passages reasonably, so that they do not have to lose profits because of the above problems. But at the same time, they should consider drivers returning to the airport and carrying passengers to other places. Short-distance taxi drivers should not only give convenience, but also impose certain constraints to form an operation mechanism. In this paper, queuing theory model and gravity coefficient prediction model will be given to solve the problem.

b. Input Processes

(1) The composition of customers may be infinite and the source of airport passenger flow cannot be determined.

(2) Airport passengers can arrive in groups or in groups.

(3) Passenger arrivals are independent of each other, i.e. previous arrivals have no effect on subsequent arrivals, otherwise they are related.

c. Queuing Rules

As far as queuing theory is concerned, its queuing rules can be divided into loss system, waiting system and mixed system. Considering the airport, when passengers leave the airport, they may encounter taxis that are not free, so they will choose other ways to leave; and sometimes they will choose to wait for a period of time until the taxis in the storage pool are free, so here we will adopt a hybrid queuing rule. When the average arrival rate of airport passengers is less than the average service rate of taxis, the system can reach a stable state. The service intensity of the whole service organization of the queuing system is as follows: $\rho = \frac{\lambda}{cu}$, as the average utilization rate of the system. When ρ is less than 1, it will not be queued infinitely, and the average arrival rate of the system is equal to the departure rate, reaching the equilibrium state.

From this, we can get the average arrival rate of passengers, waiting rate and taxi satisfaction rate.

B. Forecast Model of Total Travel Volume

The optimal short-distance taxi priority scheme uses gradient descent algorithm to set the initial number of values. $\lambda(t)$The steady-state probability under the initial number of taxis in the next year is obtained by and iteration algorithm, and then the average waiting time and load probability are obtained, and the objective function value is obtained. The gradient descent algorithm is used to reduce the short load rate continuously according to the descending direction of the objective function value, and the best solution is obtained.

Through the introduction of data, we suggest that when a taxi waits for about 30 min in the storage pool, if the short distance passenger is received, the mileage within the range of 7 km can receive the next return priority passenger code of the airport traffic management center for short distance. The validity period of the code is within 1.5h. If the taxi fails to enter the green channel passengers beyond the specified time, it will change the code. It will become invalid. By default, the driver has taken another passenger on the way. The airport can give priority to short-distance taxi pick-up according to the destination of passengers'advance booking.

V. CONCLUSION

This paper mainly analyses whether airport taxi drivers enter the "car storage pool" to wait for passengers or return empty to make decisions when they deliver passengers to the airport. A model is established to determine the factors affecting the waiting time of taxi t and the weight of the influence on t. Model 1 uses the model of entropy weighting method. Because the problem of taxi queuing for passengers and passenger queuing for boarding is relatively common, and the airport opens two-way channels for related allocation. Therefore, in order to solve this problem, we use genetic algorithm-based scheduling model to construct the genomic relationship between different passengers and different taxis, and bring data into the calculation to simulate how to arrange boarding points, passengers and taxis, so as to maximize the efficiency of riding.

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TABLE 2. RELEVANCE COEFFICIENT OF DOMAIN LEVEL INDICATORS (TWO DECIMAL POINTS)

Pearson correlation coefficient	Number of Airport "Storage Pool" Vehicles	Weather condition	Holiday and vacations	Seasonal factors	time factor	Number of arrival flights
Number of Airport "Storage Pool" Vehicles	1.00	0.43	0.64	0.52	0.48	0.79
Weather condition	0.43	1.00	0.11	0.87	0.50	0.62
Holiday and vacations	0.64	0.11	1.00	0.12	0.09	0.35
Seasonal factors	0.52	0.87	0.12	1.00	0.65	0.44
time factor	0.48	0.50	0.09	0.65	1.00	0.67
Number of arrival flights	0.79	0.622	0.35	0.44	0.67	1.00