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Analysis of Airport Taxi Problem Based on Battery Model

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Keywords: Ride Scheduling; Taxi Connection; Correlation Coefficient; Battery Model

Abstract: Taxis are one of the main means of transportation. Most domestic airports separate the drop-off (departure) and pick-up (arrival) channels. The paper does not consider factors such as peak season and off-season. The number of airport storage tanks is adjusted according to demand. Besides, it is collected and processed relevant data on the number of people entering the station to establish related models. It aims to explore the relationship between the number of parking in the ride area and the ride efficiency, verify the feasibility of the ride area scheduling model and obtain its optimal solution. It establishes a taxi airport drop-off revenue model, and collects relevant distribution data for comparison and analysis， which aim to determinate the plan of arrangement.

1. Introduction

Taxis are the main means of transport for sending (pick-up) passengers at major domestic airports. At present, most airports in China separate the send-off (departure) and pick-up (arrival) channels. The taxi driver sends the passengers to the airport and then goes to the arrival area to wait in line to take the passengers back to the city[1]. Otherwise, it chooses to return to the city to solicit passengers. Usually, the driver's decision-making is related to his personal empirical judgment. In practice, there are many deterministic and uncertain factors that affect the taxi driver's decision-making. Their correlations are different, and the effects are not the same.

2. Establishment and solution of the storage tank model

2.1 Research ideas

According to the observable data from the storage tank, regarding the number of flights arriving in a certain period of time and the number of vehicles already in the storage tank, the position status information sent by the taxi terminal can be used to obtain the empty taxi driving within a certain range around the airport[2]. The quantity, dispatching information to the taxis in this area, and then controlling the balance of supply and demand between the taxis and passengers in the airport storage pool.

2.2 Research methods

Assuming that the number of passengers waiting in line for taxis outside the storage tank is X_A, the number of passengers waiting in line for taxis outside the storage tank is X_B, the operating cycle

of the storage tank is T, and the passengers leave within one cycle The number of taxis is X_C, and the average number of passengers per taxi is y.
The waiting time for the ith taxi X_i in the queue to enter the storage pool is T_i, then

$$T_i = \{X[(X_i/X_C)] \times T \leq X < [(X_i/X_C)] \times (T+1)\} \quad (1)$$

The jth passenger $X_j$in the queue enters the boarding area and the waiting time is T_j, then

$$= \{Z[X_j/(y \times X_C)] \times T \leq Z < [X_j/(y \times X_C)] \times (T+1)\} \quad (2)$$

Assuming that the longest time a taxi driver is willing to wait outside the storage tank is T_e, and the longest time that passengers are willing to wait outside the storage tank is T_f, the waiting time T_{in} for the last taxi to enter the storage tank must be less than or equal to T_e, The waiting time T_n for the last passenger to enter the boarding area must be less than or equal to T_f.

Regardless of the influence of factors such as weather, peak season and off-season, the number of taxis in the storage tank is adjusted to meet the different needs of taxi drivers and passengers in response to different car rental needs to achieve the optimal system. Make different plans according to different passenger flows:

During peak passenger flow, X_B is larger and X_A is also very large. But $X_A \times y$ is larger thanX_B, T_n is smaller than T_f, and T_{in} is much larger than T_e, indicating that the number of empty taxis in the airport storage pool and near the airport is greater than the actual demand. Taxi drivers need to wait a lot of time, and it is necessary to reduce the number of nearby taxis entering the storage pool again. Therefore, the driver chooses A;

During peak passenger flow, X_B is larger and X_A is also very large, but $X_A \times y$ is smaller than X_B, T_n is larger than $T_n > T_f$, and $T_{in}$is much smaller than T_e. It indicates that there are more passengers in the airport and the number of empty taxis in the storage pool and near the airport is very few, which means is less than the actual demand[3]. Passengers need to wait more time, you need to add additional taxis to enter the storage tank again. Therefore, the driver of Taxi chooses B;

During peak passenger flow, X_B is larger and X_A is also very large. But $X_A \times y$ is much larger than X_B, T_n is much larger than T_f, and T_{in} is smaller than T_e, indicating that there are more passengers at the airport. There are no-load taxis in the storage pool and near the airport. The number is very small, the number of taxis in the storage pool needs to be increased, and the import and export channels of taxis should be increased. Taxi driver chooses A;

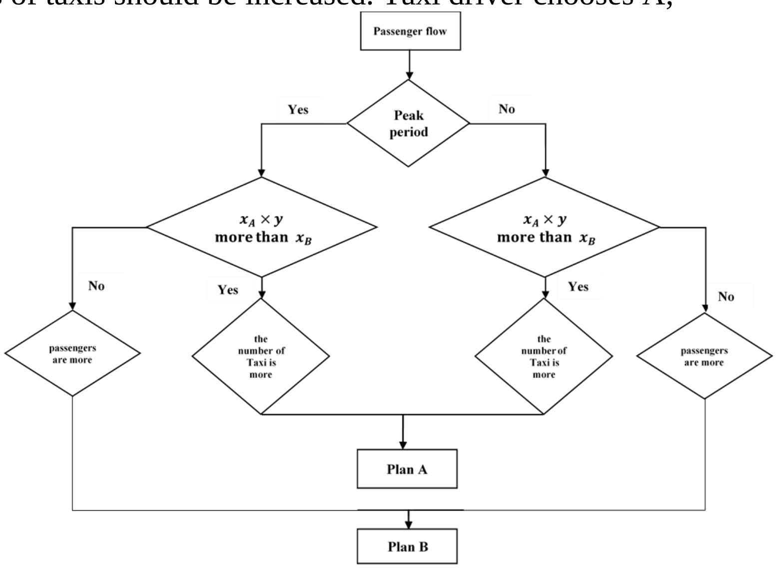

Figure 1: Scheme Selection Flow Chart

During the low peak period of passenger flow, X_B is less, $X_A \times y$ is lager than X_B, indicating that there are a lot of empty taxis in and near the airport, and there is a lot of waiting time. So you need to reduce the number of attached taxis again Enter the storage tank, taxi driver chooses B;

During the low peak period of passenger flow, X_A is small, but $X_A \times y$ is less than X_B, indicating that the number of empty taxis in and near the airport is very small, and additional taxis need to be added to enter the storage tank again. Taxi Choose option A. (As shown in Figure 1)

3. Establishment and solution of correlation model

3.1 Research ideas

It consults the relevant data on the number of people entering the station at each time of the day provided by the Beijing Transportation Bureau. Besides, it investigates the departure mode of airport passengers at a certain time of the day, collects and processes the data, and establishes the following model.

3.2 Analysis of the driver's choice plan

This paper sorts out relevant data and investigating the departure mode of airport passengers during a period of a day, and collects data and sorts out Table 1:

Table 1: Questionnaire on the Way of Departure of Airport Passengers

Questionnaire on the Number of Passengers in Major Public Transport Modes				
Time	Take a taxi	Take the Airport Bus	Take the Airport Line	Percentage of Taxi Riders
16:00--16: 10	94	33	19	64. 38%
16: 10--16:20	44	26	24	46. 81%
16: 20--16: 30	22	23	22	32. 84%
16:30--16: 40	110	34	30	63. 22%
16:40--16: 50	66	36	31	49. 62%
16:50--17: 00	95	39	28	58. 64%
17:00--17: 10	112	61	33	54. 37%
17: 10--17:20	140	67	45	55. 56%
17:20--17:30	133	39	29	66. 17%
17:30--17:40	27	31	21	34. 18%
17:40--17:50	89	30	24	62. 24%
17:50--18:00	142	38	26	68. 93%
On Average	54. 75%			

Suppose the number of people arriving at the airport is A, and the number of taxis is B. On average, each taxi takes C passengers. The number of existing taxis in the tank is D, and the theoretical number of taxis required is E.

According to the data analysis in Table 1, it can be seen that 54.75% of the passengers entering the station choose to take a taxi to leave, then:

$$B = 0.5475 \times A \tag{3}$$

$$E = B \div C \tag{4}$$

Compare D and E, choose plan B when D>E, and choose plan A when D<E.

According to the model calculation, the driver's selection plan at different time points is shown in Table 2.

4. Establishment and solution of the riding model

4.1 Analysis on the ride dispatching in the airport ride area

Table 2: Driver's Options in Various Situations

time	Number of people A	Number of taxis D	Number of taxis D	The number of taxis required theoretically E	Driver's choice plan
5:30	243	275	133	89	B
6:00	351	290	192	128	B
6:30	482	340	264	176	B
7:00	765	550	419	279	B
7:30	613	700	336	224	B
8:00	376	805	206	137	B
8:30	186	867	102	68	B
9:00	754	880	413	275	B
9:30	1140	906	624	416	B
10:00	2362	925	1293	862	B
10:30	3060	956	1675	1117	A
11:00	3249	961	1779	1186	A
11:30	3795	986	2078	1385	A
12:00	3712	953	2032	1355	A
12:30	3489	996	1910	1273	A
13:00	3348	823	1833	1222	A
13:30	3219	786	1762	1175	A
14:00	2986	755	1635	1090	A
14:30	3525	886	1930	1287	A
15:00	3571	957	1955	1303	A
15:30	3624	1056	1984	1323	A
16:00	3946	1180	2160	1440	A
16:30	4014	1235	2198	1465	A
17:00	3653	1156	2000	1333	A
17:30	3462	968	1895	1264	A
18:00	3512	952	1923	1282	A
18:30	3468	961	1899	1266	A
19:00	3396	967	1859	1240	A
19:30	3321	896	1818	1212	A
20:00	3078	912	1685	1123	A
20:30	3142	968	1720	1147	A
21:00	3043	935	1666	1111	A
21:30	3018	947	1652	1102	A
22:00	3325	1056	1820	1214	A
22:30	3487	1125	1909	1273	A
23:00	3670	1246	2009	1340	A
23:30	3824	1187	2094	1396	A
0:00	3675	1054	2012	1341	A
0:30	943	932	516	344	B
1:00	1016	756	556	371	B
1:30	632	542	346	231	B
2:00	413	320	226	151	B
2:30	213	240	117	78	B
3:00	153	180	84	56	B
3:30	132	157	72	48	B
4:00	109	196	60	40	B
4:30	98	238	54	36	B
5:00	112	256	61	41	B

The success of taxi connection involves the game of passenger waiting time, taxi waiting time, and scheduling management time. To improve ride efficiency, it is necessary to increase the capacity of the ride area or increase the number of parking spaces in the taxi ride area. In addition, the operation of the taxi in the riding area is a periodic process, which is completed by the taxi driver, passengers, and dispatcher. The specific operation content process is as follows:

(1) Taxis drive in an orderly manner and enter the parking spaces of the riding area together with the parallel taxis;

(2) The dispatcher releases the passengers to the boarding area and takes a taxi to leave;

(3) The taxi in the parking area of the boarding area must wait for the passengers to wait for the car and the taxi in the previous berth to leave before following the car;

(4) The parking space in the riding area is vacated, the cycle ends, and the next cycle begins.

A complete operation cycle in the riding area starts from the first taxi entering the parking area of the riding area to the last taxi leaving the parking area of the riding area.It is shown in the Table 2.

4.2 The establishment of the ride-hailing benefit model

In summary, the periodic behavior of the connection process in the ride area can be regarded as an organic system, and there are always three hopes in this system:

(1) The taxi driver hopes to reduce the waiting time for passengers;

(2) Passengers hope to reduce the waiting time for taxis;

(3) The dispatcher hopes to increase the number of passengers leaving from the boarding area within a unit time.

From the perspective of the system, it is necessary to balance the game relationship between the three by adjusting the dispatch plan. if the different decision-making plans of the system can have different utility for taxi drivers, passengers and dispatchers, maximizing the utility of the system is the goal of building the model.[4]

Now suppose that in the case of decision plan A, the taxi driver's passenger carrying efficiency is η_d, the passenger's riding efficiency is η_p, and the dispatcher's dispatching efficiency is η_m, and the established taxi dispatching plan's riding efficiency η_s model is:

$$\max \eta_s = \eta_d + \eta_p + \eta_m \tag{5}$$

Passengers' boarding efficiency is inversely proportional to the average waiting time for a taxi to leave:

$$\eta_d = -k_{taxis} T_{taxis}^{\alpha} \tag{6}$$

k_{taxis} Is a non-negative coefficient, α is a non-negative constant.

The dispatcher's dispatching efficiency η_m is proportional to the capacity $k_{taxis}\, Q_{capacity}$ of the ride area:

$$\eta_m = k_{capacity} Q_{capacity}^{\gamma} \tag{7}$$

$k_{capacity}$ is a non-negative coefficient, γ is a non-negative constant.

The functional form of the total ride efficiency of the ride area can be written as:

$$\max \eta_s = -k_{taxis} T_{taxis}^{\alpha} - k_{passengers} T_{passengers}^{\beta} + k_{capacity} Q_{capacity}^{\gamma} \tag{8}$$

4.3 Analysis of the scheduling model

In most cases, the three behavioral processes of the ride area dispatching are:

(1) The process of forming a fleet of taxis from outside the riding area and entering the parking spaces of the riding area to wait for passengers

Its driving-in time is $t_{\text{Drive in}}$,then the time for the taxi to enter the $t_{n\text{Drive in}}$ th berth to stop and wait for passengers is, then:

$$t_{n\text{Drive in}} = \text{n} \cdot t_{\text{Driving}} + t_{\text{Driving}} + t_{\text{brake}} \tag{9}$$

$t_{\text{Drive in}}$ is the time when the taxi starts the vehicle; t_{brak} is the time when the taxi stops; t_{Driving} is the time when the taxi corresponding to the n berth drove to the berth.

It can be assumed that the size of the berth is the same as the size of the taxi, then:

$$t_{\text{drive in}} = G_x \cdot L / v_{\text{taxi}} \tag{10}$$

L is the length of the berth; v_{taxi} is the speed of the vehicle.

(2) The waiting process of taxi in the boarding area

The waiting time can be set as t_{waiting} : waiting, then the waiting time $t_{n\text{waiting for passengers}}$ of the taxi in the nth berth is determined by two factors: whether the passengers taking the taxi in the nth berth have finished boarding; whether the taxi in the n-1th berth is carrying passengers and leaving, which is:

$$t_{n\text{waiting for passengers}} = \max(t_{n\text{get on}},\ t_{n-1\text{get on}} + t_{\text{starting up}}) \tag{11}$$

($t_{n\text{get on}}$ is the travel time of the passenger taking the taxi at berth n)

That is, the total time to get on the bus:

$$t_{n\text{get on}} = t_{n\text{pass through}} + t_{n\text{get out}} + t_{\text{Luggage}} + t_{\text{Boarding}} \tag{12}$$

Time to place luggage for passengers is t_{Luggage}; Time to open doors for passengers to board the bus is t_{Boarding};

$t_{n\text{pass through}}$ is the time when the passenger taking the taxi at the nth berth walks from the queue to the exit, namely:

$$t_{n\text{pass through}} = G_y \cdot n \cdot J_{\text{carry}} \cdot t_{\text{put}} \tag{13}$$

$t_{\text{pass through}}$ is the average time taken by the dispatcher to release each passenger at the exit; $t_{n\text{get out}}$ is the time taken for the passenger taking the taxi at the nth berth to walk from the release exit to the taxi position at the nth berth:

$$t_{n\text{pass through}} = \left| n - A_{\text{Export}} \right| \cdot L / v_{\text{Export}} \tag{14}$$

A_{Export} is the number of taxi berths facing the clearance exit; v_{person} is the average speed of passengers moving.

(3) The process of leaving the riding area after the taxi has finished carrying passengers

Suppose the time for the taxi at berth n to leave the boarding area with passengers as $t_{n\text{Drive away}}$ namely:

$$t_{\text{nDrive away}} = n \cdot L / v_{\text{taxi}} + t_{\text{start}} \quad (15)$$

Assuming that in the riding area scheduling cycle, after the taxi corresponding to the nth berth brakes smoothly at the berth, the passenger team release exit starts to be released. The riding area scheduling cycle T is:

$$T = t_{\text{nDrive in}} + t_{n\text{wait for passengers}} + t_{\text{nDrive away}} \quad (16)$$

4.4 Relevance of the ride area

When the number of lanes in the airport boarding area is 2, the capacity of the boarding area is calculated, assuming that the relevant parameters of the dispatch period T are as shown in Table 3:

Table 3: Values of Undetermined

Pending parameters	Value
Time for the taxi to start the vehicle (s)	2
Taxi parking time (s)	2
Vehicle speed (m/s)	3
Time for passengers to place their luggage (s)	15
Boarding time(s)	5
Average speed of passengers moving (m/s)	1.4
Average number of taxi riders) (persons)	1.5
The average time taken by the dispatcher to release each passenger at the exit (s)	1
Vehicle length (m)	5

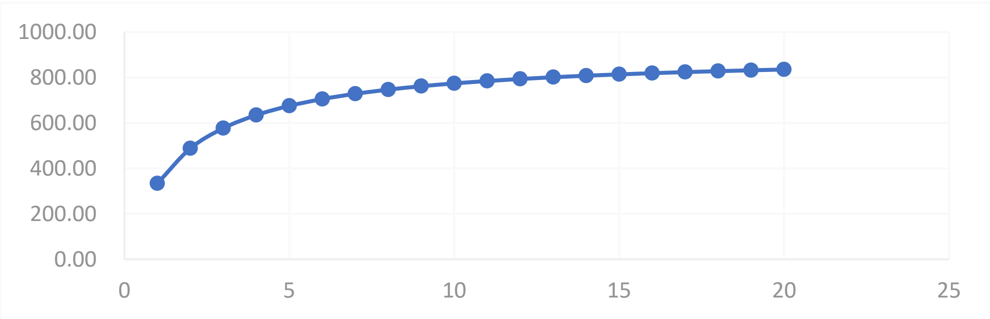

Figure 2: The relationship between capacity and the number of parking spaces in a single lane

Suppose the berth directly opposite the passenger clearance exit of the riding area is berth 1, and the waiting time for taxis at the nth berth is $t_{n\text{get on}}$. Under the relevant parameters in the above table, the number of parking spaces in the riding area is increased from 1 to 20, correspondingly The calculation results of arrival time, waiting time, departure time, dispatch period, and passenger transportation capacity are shown in the following Table 4 and Figure 2.

The relationship between the number of parking spaces in the riding area and the capacity of taxis is separately considered. The number of parking spaces in a single lane is used as the abscissa and the capacity is used as the ordinate to draw the graph. It can be seen from Figure 6 that the capacity increases with the increase in the number of berths, which is in line with our daily experience, but the increase is gradually reduced.

Table 4: Calculation results of entry time, waiting time, departure time, dispatch period and capacity

Number of parking spaces in a single lane	Drive in(s)	Wait for passengers(s)	Drive away(s)	cycle(s)	Capacity (vehicles)
1	5.67	23	3.67	32.33	334.02
2	9.33	29.57	5.33	44.24	488.27
3	13	36.17	7	56.14	577.1
4	16.67	42.71	8.67	68.05	634.85
5	20.33	49.29	10.33	79.95	675.4
6	24	55.86	12	91.86	705.44
7	27.67	62.43	13.67	103.76	728.59
8	31.33	69	15.33	115.67	746.97
9	35	75.57	17	127.57	761.93
10	38.67	82.14	18.67	139.48	774.33
11	42.33	88.71	20.33	151.38	784.78
12	46	95.29	22	163.29	793.7
13	49.67	101.86	23.67	175.19	801.41
14	53.33	108.43	25.33	187.1	808.14
15	57	115	27	199	814.07
16	60.67	121.57	28.67	210.9	819.33
17	64.33	128.14	30.33	222.81	824.02
18	68	134.71	32	234.71	828.24
19	71.67	141.29	33.67	246.62	832.05
20	75.33	147.86	35.33	258.52	835.51

Then draw the relationship between the number of parking spaces in a single lane and the average waiting time of taxis in the cycle, the number of parking spaces in a single lane and the average waiting time of passengers in the cycle into tables and curves (as shown in Figures 3, 4 and Table 5, 6):

Table 5: Calculation results of average driver time

the number of parking spaces in a single	The nth driver' s waiting time																				the average waiting time of drivers
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	32.33																				32.33
2	37.57	44.24																			40.9
3	42.81	49.48	56.14																		49.48
4	48.05	54.71	61.38	68.05																	58.05
5	53.29	59.95	66.62	73.29	79.95																66.62
6	58.52	65.19	71.86	78.52	85.19	91.86															75.19
7	63.76	70.43	77.10	83.76	90.43	97.10	103.76														83.76
8	69	75.67	82.33	89	95.67	102.33	109	115.67													92.33
9	74.24	80.90	87.57	94.24	100.9	107.57	14.24	120.90	127. 57												100.9
10	79.48	86.14	92.81	99.48	106.14	112.81	119.48	126.14	132.81	139. 48											109, 48
11	84.71	91. 38	98.05	104.71	11.388	118.05	124.71	131.38	138.05	144.71	151.38										118.05
12	89.95	96.62	103.29	109.95	116.62	123.29	129.95	136.62	143.29	149.95	156.62	163. 29									126. 62
13	95.19	101.86	108.52	115.19	121.86	12852	135.19	141.86	148.52	155.19	161.86	168.52	175. 19								135.19
14	100.43	107.1	113.76	120.43	127.1	133.76	140.43	147.1	153.76	160.43	167.1	173.76	180.43	187. 10							143. 76
15	105.67	112.33	119	125.67	132.33	139	145.67	152.33	159	165.67	172.33	179.00	185.67	192.33	199						152, 33
16	110.9	117.57	124.24	130.90	137.57	144.24	150.9	157.57	164.24	170.90	177.57	184.24	190.90	197.57	216.14	22.81					160. 90
17	116.14	122.81	129.48	136.14	142.81	149.48	156.14	162.81	169.48	176.14	182.81	189.48	196.14	202.81	209.48	216.14	22.81				169. 48
18	121.38	128.05	134.71	141.38	148.05	154.71	161. 38	168. 05	174.71	181.38	188.05	194.71	201.38	208.05	214.71	221.38	228.05	22.81			178.05
19	126.62	133.29	139.95	146.62	153.29	159.95	166.62	173.29	179.95	186.62	193.29	199.95	206.62	213.29	219.95	226.62	233.29	239.95	246. 62		186.62
20	131.86	138.52	145.19	151.86	158.52	165.19	171.86	178.52	185.19	191.86	198.52	205.19	211.86	218.52	225.19	231.88	238.52	245.19	251.86	258.52	196. 19

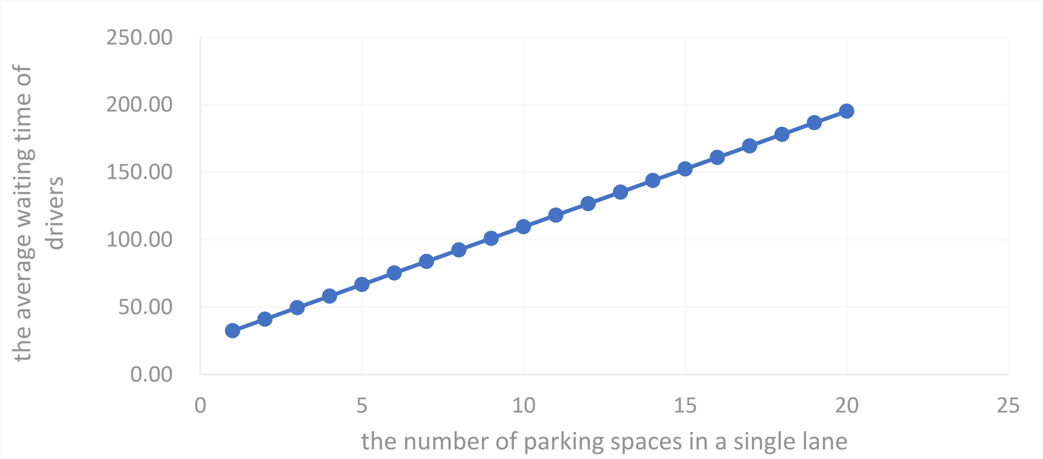

Figure 3: The relationship between the average waiting time of drivers and the number of parking spaces in a single lane

Table 6: Results of the average waiting time of passengers

the number of parking spaces in a single lane	the waiting time of Berth n passenger																				the average waiting time of passengers
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	32.33																				32.33
2	37.57	44.24																			40.9
3	42.81	49.48	56.14																		49.48
4	48.05	54.71	61.38	68.05																	58.05
5	53.29	59.95	66.62	73.29	79.95																66.62
6	58.52	65.19	71.86	78.52	85.19	91.86															75.19
7	63.76	70.43	77.10	83.76	90.43	97.10	103.76														83.76
8	69	75.67	82.33	89	95.67	102.33	109	115.67													92.33
9	74.24	80.90	87.57	94.24	100.9	107.57	14.24	120.90	127. 57												100.9
10	79.48	86.14	92.81	99.48	106.14	112.81	119.48	126.14	132.81	139. 48											109, 48
11	84.71	91. 38	98.05	104.71	11.388	118.05	124.71	131.38	138.05	144.71	151.38										118.05
12	89.95	96.62	103.29	109.95	116.62	123.29	129.95	136.62	143.29	149.95	156.62	163. 29									126. 62
13	95.19	101.86	108.52	115.19	121.86	12852	135.19	141.86	148.52	155.19	161.86	168.52	175. 19								135.19
14	100.43	107.1	113.76	120.43	127.1	133.76	140.43	147.1	153.76	160.43	167.1	173.76	180.43	187. 10							143. 76
15	105.67	112.33	119	125.67	132.33	139	145.67	152.33	159	165.67	172.33	179.00	185.67	192.33	199						152, 33
16	110.9	117.57	124.24	130.90	137.57	144.24	150.9	157.57	164.24	170.90	177.57	184.24	190.90	197.57	216.14	22.81					160. 90
17	116.14	122.81	129.48	136.14	142.81	149.48	156.14	162.81	169.48	176.14	182.81	189.48	196.14	202.81	209.48	216.14	22.81				169. 48
18	121.38	128.05	134.71	141.38	148.05	154.71	161. 38	168. 05	174.71	181.38	188.05	194.71	201.38	208.05	214.71	221.38	228.05	22.81			178.05
19	126.62	133.29	139.95	146.62	153.29	159.95	166.62	173.29	179.95	186.62	193.29	199.95	206.62	213.29	219.95	226.62	233.29	239.95	246. 62		186.62
20	131.86	138.52	145.19	151.86	158.52	165.19	171.86	178.52	185.19	191.86	198.52	205.19	211.86	218.52	225.19	231.88	238.52	245.19	251.86	258.52	196. 19

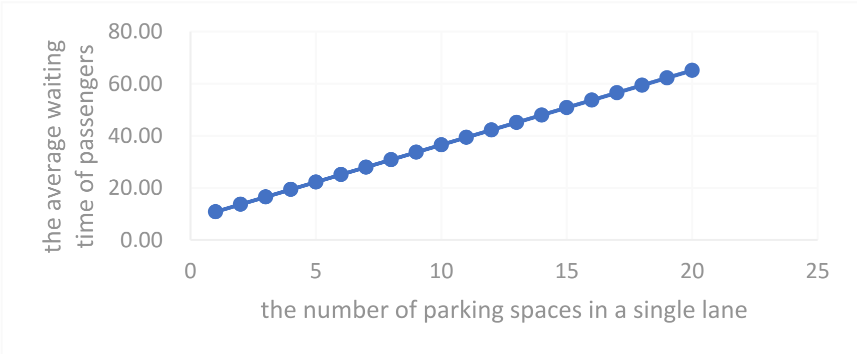

Figure 4: The relationship between the average waiting time of passengers and the number of parking spaces in a single lane

It can be seen from the above chart that the average waiting time of taxis and the average waiting time of passengers basically have a linear growth relationship.

4.5 Actual calculation of the ride efficiency model

The above modeling shows that the waiting time of taxi drivers, waiting time of passengers, and the capacity of the riding area in the taxi riding area dispatching system are all related to the number of parking spaces in the riding area, which can be summarized as:

(1) The more taxi berths in the riding area, the greater the traffic capacity of the road, but as the number of berths increases, the rate of increase and change in traffic capacity gradually decreases;

(2) The more taxi berths in the riding area, the longer the operation time of the scheduling cycle in the riding area, and the relationship between the two is linearly increasing. The waiting time of the taxi driver and the waiting time of the passengers in the cycle are both the same[5]. The scheduling operation cycle is related. That is, the waiting time of the taxi driver and the waiting time of the passengers are related to the number of parking spaces in the boarding area.

Analyze the ride efficiency of the ride area, by formula:

$$\max \eta_s = -\mathrm{k}_{\text{taxi}} T_{\text{taxi}}^{\alpha} - \mathrm{k}_{\text{passengers}} T_{\text{passengers}}^{\beta} + \mathrm{k}_{\text{capability}} Q_{\text{capability}}^{\gamma} \tag{17}$$

The coefficient can have the following assumptions, As it is shown in Table 7:

Table 7: Table of Parameter Values

Pending parameters	Value
K taxi	0.50
α taxi	0.25
K passenger	0.50
β passenger	0.25
K Capacity	1.00
γ Capacity	0.25

Under the conditions of the above parameters, the direct relationship between the different numbers of parking spaces in the riding area and the riding efficiency of the dispatching system can be obtained (as shown in Figure 5):

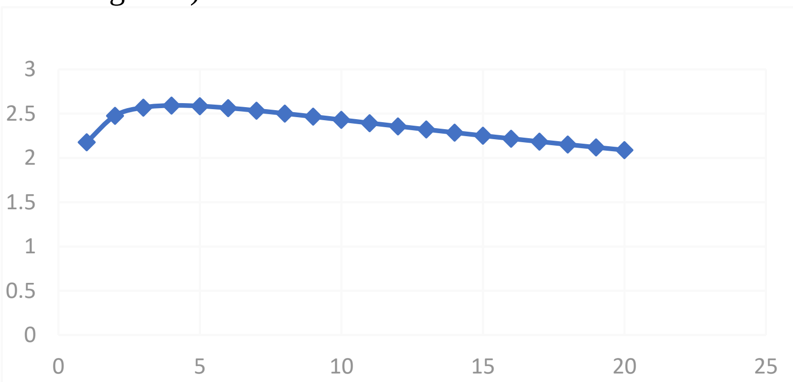

Figure 5: The relationship between the number of berths and ride efficiency

The analysis chart shows that as the number of parking spaces in the riding area increases, the ride efficiency of the dispatch system first increases and then decreases. Under the above conditions, when the number of parking spaces in a single lane is 4, the ride efficiency of the system dispatch reaches the maximum value. Therefore, in this example, the most appropriate number of single-lane parking spaces is 4. That is, when the management department sets the number of "pick-up points" in the riding area to 8, the overall riding efficiency can be maximized.

5. Establishment and solution of taxi revenue model

5.1 Research ideas

We firstly established a revenue model for taxis leaving the airport to drop off passengers. Then, it compared and analyzed the collected data on the passenger destination distribution of Chengdu Shuangliu Airport. It obtained a short distance that is more balanced for Shuangliu Airport taxi drivers in terms of time and revenue. Finally, it completed the management department's "priority" arrangement plan was determined.

4.2 Establishment Method

The operating income of airport taxis is often closely related to the distance traveled by passengers. The destinations reached by passengers vary. In the case that the taxi driver is unable to select passengers and refuses to carry[6], the analysis of the "priority" given by the relevant authorities to the return of passengers for short-distance taxis is as follows:

Assuming that the taxi driver's revenue is E_{revenue}, the amount indicated by the taxi timer when carrying passengers is M_{amount}, and the fuel consumption cost of the taxi to the destination is $S_{\text{fuel consumption cost of the taxi}}$ the model of taxi revenue is:

$$E_{\text{Revenue}} = M_{\text{amount}} - S_{\text{fuel consumption cost of the taxi}} \tag{18}$$

In the above formula:

The amount M_{amount} indicated by the taxi timer is related to the distance traveled as follows:

$$M_{\text{amount}} = M_{\text{Taxi starting price}} + k_{\text{taxi}} x^{\sigma} \tag{19}$$

M_{amount} $M_{\text{Taxi starting price}}$ is the taxi starting price, k_{taxi} is a non-negative coefficient, and σ is a non-negative constant; The fuel consumption cost $S_{\text{fuel consumption cost of the taxi}}$ of a taxi to the destination is related to the distance traveled as follows:

$$S_{\text{fuel consumption cost of the taxi}} = k_{\text{fuel}} x^{\mu} \tag{20}$$

k_{fuel} is a non-negative coefficient and μ is a non-negative constant.

Then the taxi revenue E_{revenue} can be written as:

$$E_{\text{revenue}} = M_{\text{Taxi starting price}} + k_{\text{taxi}} x^{\sigma} - k_{\text{fuel}} x^{\mu} \tag{21}$$

According to the collected Chengdu taxi data, a total of 270 taxis were tracked and recorded, the final data sample was obtained. The range of Shuangliu Airport located on the map is east longitude: (103.953917---103.974924) north latitude: (30.546305---30.5745152), as shown in Figure 10 (the white marked square is the airport area):

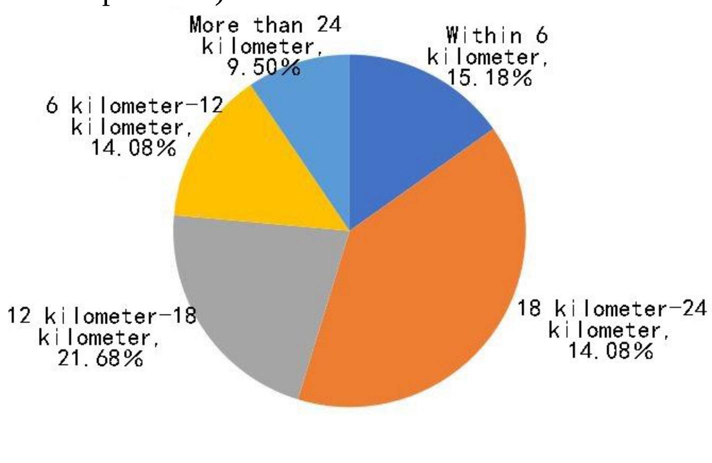

Figure 6: Pie chart of the number of passengers at different destination distances

Floating car GPS data has large capacity and rich information. It needs to be classified and filtered by program software. The collected GPS data of Chengdu taxis can be processed by MATLAB mathematics software, and the data on August 20, 2014 Analyze the proportional relationship between the taxi destination and the distance from the airport,It is shown in the Figure 6.

At present, the pricing standard for class B taxis in Chengdu is: the starting price is 8 yuan for the distance within 2km (including 2km), the distance beyond 2km is charged at 1.9 yuan/km, but the distance beyond 10km needs to be charged 50% The return fee of the taxi (that is, the unit price is 1.9×(1+50%)=2.85yuan/km). According to the survey, the fuel consumption cost of the taxi is 0.5 yuan per kilometer, and the taxi speed is 25km/h.

Let Y be the amount and x be the distance

$$Y = \begin{cases} 8 - 0.5X(0 < X \leq 2) \\ 4.2 + 1.4X(2 < X \leq 10) \\ 2.35X - 5.38(X > 10) \end{cases} \quad (22)$$

Suppose the driver has finished seeing off the passengers. Immediately， they return to the airport with an empty car, and the return after the change is as follows:

$$Y = \begin{cases} 8 - X(0 < X \leq 2) \\ 4.2 + 0.9X(2 < X \leq 10) \\ 1.85X - 5.38(X > 10) \end{cases} \quad (23)$$

The destination choice of the passengers picking up for the second time still obeys the probability distribution of the pie chart. According to the calculation of the formula, the median value of the income is 25 yuan, and the income and time are relatively balanced. Substituting the above formula, the short-distance distance is calculated as 16.5 kilometers. $S = vt$ Get T_{back} =2t = 1.2h.

According to the results of the above calculations, in order to ensure that the revenue of taxis is as balanced as possible. The relevant departments can give “priority” arrangements to taxis that return within 1.2 hours of leaving the airport.

6. Conclusion

The models established for different problems and actual conditions are highly consistent with the actual situation. The model establishment is in line with the actual background and is innovative. It has a certain reference value for solving airport taxi scheduling and management problems. Due to changes in the reference data in reality, there will be certain errors. Therefore, the improvement when using the model should be updated with data, and the actual influencing factors such as weather should be added to the reference model.

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