Improvement Method of Service Productivity for Taxi Company

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Abstract. We propose improvement method of service productivity for Taxi Company of rearranging taxi drivers working hours. There are two ways a taxi company gets customers. One is to deliver taxi for a telephone request, and the other is to get customers on street. In Japan, there are many taxi companies where the ratio of the former method is higher. Therefore we research rearrangement method of the taxi drivers working hours so as to operate many taxis with many telephone requests. We find it effective strategy to increase taxi drivers in midnight and early morning with many customers per taxi instead of decreasing taxi drivers in daytime with few customers per taxi.

Keywords: service productivity, taxi company, rearrangement working time, simulation, staff scheduling

1 Introduction

In recent years, it became very severe to get customer between taxi companies in Japan. The number of taxis is increased, because it was easy to start Taxi Company from 2002 by regal revision, but customers decreased. As a result, income of a taxi per day was decreased (see Fig.1). Then taxi companies introduce various method to gain customers, for example, customer membership, information system for efficient

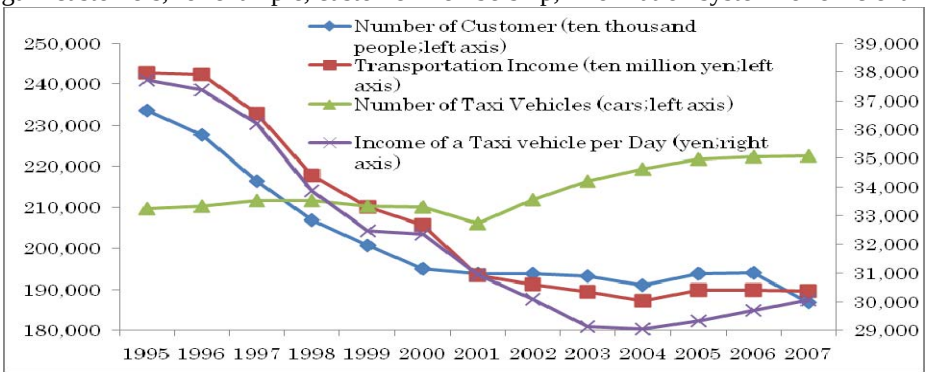

Fig. 1. Income of taxi per day

taxi operation [1][2]. There are many taxi companies which introduce a taxi operation system using GPS and radio system to shorten taxi waiting time. But taxi waiting time couldn't be shortened, if the operation demands of a taxi exceed the number of taxis which can be worked. Furthermore, there is a problem that suitable service arrangement method is not established to the operation demands of a taxi. From above reason, we analyze telephone requests data and taxi operation data from the Taxi Company, and research taxi driver arrangement method to improve service productivity.

In this paper, we analyze present situation of the Taxi Company which we research (we call Company A in this paper), research improvement method of rearranging taxi drivers working hours using computer simulation, and verify validity of our method.

2 Subjects of Company A

2.1 Taxi Driver's Working Hours for Company A

Leaving and returning garage time according to taxi driver's service pattern of Company A are shown in Table 1. Taxi driver's service pattern consists of four groups, such as Shift, Day, Fixed time, and Night.

In Shift, taxi drivers change service pattern Ⅰ, Ⅱ, Ⅲ, Ⅳ, and Free by every other day. In Day, taxi drivers work from Monday to Saturday. In Fixed time, taxi drivers change working group A and B in each week. They work on Monday, Wednesday, and Friday in group A, Tuesday, Thursday, and Saturday in group B. In Night, taxi drivers work on "Monday, Wednesday, Friday" and "Tuesday, Thursday, Saturday" in each week or work on Friday and Saturday every week.

Table 1. Leaving and returning garage time

Service pattern		Leaving	Returning	Total working hours
Shift	Ⅰ	7:00	1:00	18hours
	Ⅱ	8:00	2:00	18hours
	Ⅲ	8:00	3:00	19hours
	Ⅳ	12:00	8:00	20hours
	Free	7:00	24:00	17hours
Day		7:00	19:00	12hours
Fixed time		7:00	21:00	14hours
Night		20:00	4:00	8hours

Furthermore, there is the following detailed rule.

(a) Although Free is originally no working day, if the taxi driver wishes, they can freely work between 7:00 and 24:00.
(b) Since the cleaning car time is also contained in working hours, taxi drivers finish the taxi operation 1 hour before returning garage time. However, they drive taxi as working hours only on Friday and Saturday from the 20th till the end of the month, because there will be many customers.

2.2 Subjects of Company A

There are two customer acquisition methods for Taxi Companies in Japan. One is to deliver a taxi for a telephone request, and the other is to get customers on street. For the former method, it is required to deliver a taxi immediately by telephone a request. For the latter method, it is required to allocate taxis for a place with many customers who need a taxi. In Japan, there are many taxi companies whose customer acquisition ratio of former method is higher than latter one. We research a service system with which many taxis work in time zone with many telephone requests.

In order to extract present subjects, we analyze the number of telephone requests per taxi in every hour (we call it load) shown in (1).If load is high, taxis for telephone requests are short, and if low, taxis are enough.

$$L_{ijk} = \frac{R_{ijk}}{T_{ijk}} \tag{1}$$

L_{ijk} : Load per taxi on *i*-month *j*-day *k*-time
R_{ijk} : The number of telephone requests on i-month j-day k-time
T_{ijk} : The number of taxis which can be worked on i-month j-day k-time

We get telephone request data from Company A, and calculate the number of telephone requests per hour, day of the week, and load based on (1), respectively. From Fig.2 and Fig.3, we find out subjects of Company A as follows.

(a) The peak hours of the number telephone requests and load differ (See Fig.2).
(b) The distribution according to day of the week of telephone requests and load is almost the same. They are high on Friday and Saturday (See Fig.3).

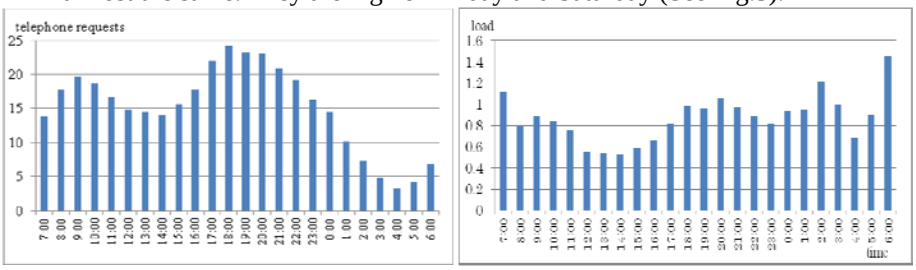

Fig. 2. The number of telephone requests (left Fig.) and load (right Fig.) per hour

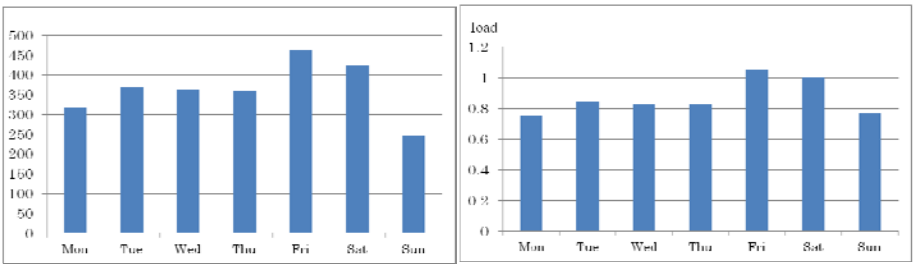

Fig. 3. The number of telephone requests (left Fig.) and load (right Fig.) per day of the week

3 Improvement Method of Customer Acquisition

From present data analysis, if the number of taxis which can be worked on high load time zone or day of the week is increased, "delivering a taxi immediately for a telephone request" will become possible, and service productivity will increase. Increasing the number of taxi drivers increases labor cost, and it may become rising income and falling profits. Therefore, we decide to rearrange the taxi driver's working hours without increasing the number of taxi drivers.

This problem is formulated as staff scheduling problem. There are several research results for nurse scheduling problem which is one of the staff scheduling problems. In previous research, optimum solution method to minimize the number of constraints violation was researched [3][4]. In this research we research method to minimize the summation of load described in (1). Therefore we choose computer simulation analysis to work many taxis in the time zone with many telephone requests. In addition, we research the methodology which can be applied to the other taxi companies.

3.1 Computer Simulation Cases

It turns out that the peak hours of the number of taxi which can be worked and telephone requests differ. We research service system so as to increase taxi drivers with high load and decrease taxi drivers with low load according to five simulation cases on condition that the service pattern is not so much different from the present one.

(a) Case1

[Method] Every leaving and returning garage time of all service patterns are shifted 1 hour before.
[Purpose] The number of taxi drivers with high load, such as 6:00 to 7:00, is increased.

(b) Case2

[Method] Leaving and returning garage time of Day and Fixed time are shifted 1 hour before.
[Purpose] The number of taxi drivers with high load, such as 6:00 to 7:00, is increased, only on Day and Fixed time because those flexibility of change is high in Taxi Company A.

(c) Case3

[Method] Taxi driver's working time of 12:00 to 16:00 in Fixed time is changed to 3:00 to 6:00 or 22:00 to 2:00.
[Purpose] The number of taxi drivers with high load, such as 3:00 to 6:00 or 22:00 to 2:00, is increased. The number of taxi drivers with low load, such as 12:00 to 16:00, is decreased.

Table 2. Considerable patterns for each case

Case	Considerable Patterns
1	(a)1 hour before[*1)]
2	(a)1 hour before(Service pattern: Day), (b)1 hour before(Service pattern: Fixed time), (c)both (a) and (b)
3	(a)1 hour before, (b)1 hour after, (c)2 hours before, (d)2 hours after, (e)1hours before and 1hour after, (f)3 hours before (g)3 hours after, (h)2 hours before and 1 hour after, (i)1 hour before and 2 hours after, (j)4hours before (k)4 hours after
4	(a)A[*2)]:Mon,Wed,Fri B:Tue,Fri,Sat or Thu,Fri,Sat, (b)A:Mon,Fri,Sat or Wed,Fri,Sat B:Tue,Thu,Sat, (c)A:Mon,Fri,Sat B:Tue,Fri,Sat, (d)A:Wed,Fri,Sat B:Tue,Fri,Sat, (e)A:Mon,Fri,Sat B:Thu,Fri,Sat, (f)A:Wed,Fri,Sat B:Thu,Fri,Sat
5	(a)One taxi driver is changed, (b)Two taxi drivers are changed, (c)Three taxi drivers are changed

*1) Leaving and returning garage time are shifted 1 hour before.
*2) "A" means Group A.

Table 3. Example (1 hour before)

Non-working hours	Working hours
From 12:00 to 13:00	From 6:00 to 12:00, From 13:00 to 21:00
From 13:00 to 14:00	From 6:00 to 13:00, From 14:00 to 21:00
From 14:00 to 15:00	From 6:00 to 14:00, From 15:00 to 21:00
From 15:00 to 16:00	From 6:00 to 15:00, From 16:00 to 21:00

(d) Case4

[Method] Taxi driver's working day of Monday to Thursday in Fixed time is changed to Friday or Saturday.

[Purpose] The number of taxi drivers with high load day, such as Friday or Saturday, is increased.

(e) Case5

[Method] According to the Taxi Company A's know-how, taxi driver's working pattern is changed as follows.

・Taxi driver's working pattern Free on Friday or Saturday is changed to working pattern Ⅰ on Sunday or Monday.

・Taxi driver's working pattern Ⅲon Friday or Saturday is changed to working pattern Ⅳ on Sunday or Monday.

[Purpose] The number of taxi drivers with high load day, Friday or Saturday, is increased.

We verify all considerable patterns about change of time, day of the week, or the number in each simulation cases (see Table 2). Furthermore, in case3, considerable pattern is subdivided by non-working hours between 13:00 and 16:00 (See Table3).

We find out the best taxi drivers working hours which minimizes the summation of load described in (1) from 42 simulation patterns.

3.2 Simulation Results

Top 5 patterns in 42 simulation patterns using telephone request data in 2010/1 to 2010/10 from the Company A are shown in Table4. All of them belong to Case3.
Load average and load variance of top 5 patterns are improved compared with the present situation. Load per hour of the best pattern, such as 4 hours before, is shown in Fig.4. We find the following results compared with the present situation shown in Fig.2. The load between 4:00 to 5:00 and 6:00 to 7:00, which is high in the present situation, decreases. Especially, the load between 6:00 to 7:00 decreases to less than 1.0 from 1.4. It causes a little enough time in taxi operation. Taxi driver must drive a round trip under 40 minutes to achieve 1.4 taxi operations per 1 hour. On the other hand, taxi driver drives a round trip in 60 minutes to achieve 1.0 taxi operation per 1 hour. The load between 12:00 to 16:00 remains 0.6 times per hour. Namely, load doesn't increase in daytime steeply.

It turns out that it is effective strategy to increase taxi drivers in midnight and early morning with high load instead of decreasing taxi drivers in daytime with low load so as to gain customers who reserves taxi by telephone requests.

Table 4. Top 5 patterns

Rank	Pattern	Working hours	Load average	Load variance
1	4 hours before	3 – 12, 16 – 21	0.820796	0.227361
2	3 hours before, 1 hour after	4 – 12, 16 – 22	0.828395	0.233268
3	3hours before	4 – 12, 15 – 21	0.831021	0.237765
4		4 – 13, 16 – 21	0.831176	0.237569
5	2hours before, 2hours after	5 – 12, 16 – 23	0.832495	0.230137
–	present situation	–	0.868584	0.283285

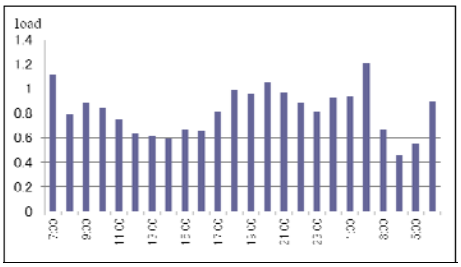

Fig. 4. Load per hour (4 hours before)

3.3 Verification of the Validity of Simulation Results

We verify the validity of simulation results using the other data from the Taxi Company A. We use all of the taxi operation data (e.g. telephone requests and getting customers on street) in 2010/2 to 2011/1. The reason for using all of the taxi operation

data is for checking whether a problem appears for in customers who get a taxi on street in daytime, when the number of taxi which can be worked in daytime is decreased.

Top 5 patterns of 42 simulation patterns which are same case as 3.2 are shown in Table5. Load average and load variance of top 5 patterns are improved compared with the present situation. Although the 3rd place and the 4th place of ranking are changed, top 5 patterns are same patterns as results in 3.2. Load per hour of the best pattern, such as 4 hours before, is shown in left Fig. of Fig.5. We find the following results compared with the present situation shown in right Fig. of Fig5. The load between 6:00 to 7:00, when load is high in the present situation, decreases to 1.2 from 2.0. It causes a little enough time in taxi operation. Taxi driver must drive a round trip under 30 minutes to achieve 2.0 taxi operations per 1 hour. On the other hand, taxi driver drives a round trip in 50 minutes to achieve 1.2 taxi operations per 1 hour. The load between 12:00 to 15:00 remains 1.0 times per hour. Namely, load doesn't increase in daytime steeply.

Table 5. Top 5 patterns of all the taxi operation data

Rank	Pattern	Working hours	Load average	Load variance
1	4 hours before	3 – 12, 16 – 21	1.207361	0.365542
2	3 hours before, 1 hour after	4 – 12, 16 – 22	1.216663	0.367898
3	3hours before	4 – 13, 16 – 21	1.218303	0.371616
4		4 – 12, 15 – 21	1.219509	0.373924
5	2hours before, 2hours after	5 – 12, 16 – 23	1.219803	0.356295
–	present situation	–	1.262712	0.394881

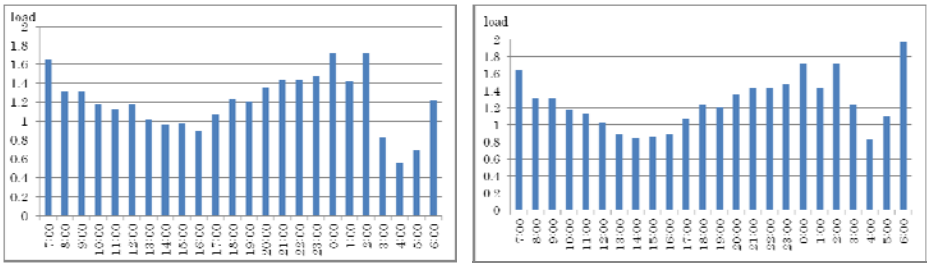

Fig. 5. Load per hour (4 hours before (left Fig.) and present situation (right Fig))

3.4 Subjects of Applying New Strategy to Taxi Drivers

From above discussion, it is effective strategy to increase taxi drivers in midnight and early morning with high load instead of decreasing taxi drivers in daytime with low load. Applying this strategy, load descried in (1) decreases and service productivity is improved. There are non-working hours in working hours of Fixed time. For example, taxi drivers work from 3:00 to 12:00, don't work from 12:00 to 16:00, work from 16:00 to 21:00 in the best pattern. We suppose that it is difficult for taxi drivers to receive this service pattern. Therefore, we design new service pattern for Fixed time.

We divide one working hours of Fixed time into two working hours, such as “a.m. working hours” and “p.m. working hours”, rotate working groups of Fixed time across Sunday (See Fig.6). This service pattern enables taxi drivers to secure the same working hours per one month as the present service pattern, without non-working hours between working hours.

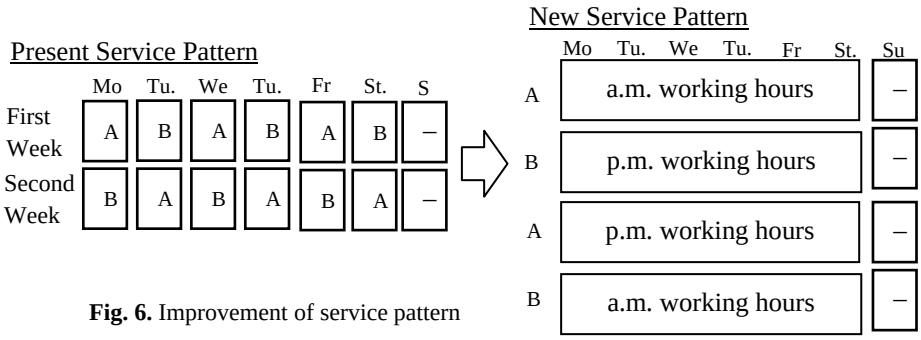

Fig. 6. Improvement of service pattern

4 Conclusions

We research service methodology so as to improve service productivity in Taxi Company. For the above mentioned purpose, we research improvement method of rearranging taxi driver’s working hours so as to work many taxis with many taxi delivery demands by telephone requests. Using telephone request data from Taxi Company A, we analyze present situation of Taxi Company A, and perform simulation analysis so as to minimize the taxi delivery demand per taxi and hour. As a result, it turns out that it is effective strategy to increase taxi drivers in midnight and early morning with high load instead of decreasing taxi drivers in daytime with low load. Finally, we consider the management measure to subject of applying this strategy to taxi drivers.

We will research the optimal arrangement of the taxi waiting position in the taxi operating area which is another measure so as to improve service productivity of Taxi Company.

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