P&R siting and pricing plan taking consider of bus utilizers

Kyushu University Student Member Yang Zhengzheng
Kyushu University Regular Member Satoshi Toi

1. Introduction

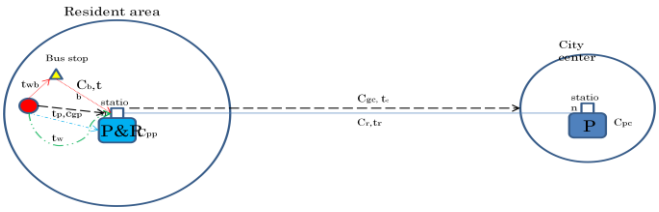
With the construction of the P&R facilities, people who used to travel by bus or taking bus from residential area to the nearest railway station then take a train to the city center, which can be named as bus-and-ride, will change their travel mode to P&R [1]. However, this evidence will lead to a result which city planners and bus companies would not like to face: the utilization of bus will decrease; market sharing of public transportation in branch area of the city will be occupied by P&R facilities. This could make the operation of bus companies to a plight situation. If the situation getting worse, there will be a possibility that the bus companies go bankrupt or the bus lines running through the area where P&R facility located will be canceled. It will turn to a big problem for residents who cannot drive.

2. Purpose

Due to the trend of travel mode switching, bus running will go corner, which will lead to an inconvenient travel for bus utilizers. To solve this problem, a proper P&R facility siting and pricing plan should be made, which will attract car drivers change their travel mode to public transportation, at the same time, the P&R facility will not or have little effect to bus running in its sphere of influence.

3. Travel mode analysis

In this research, we mainly discuss a proper P&R facility siting and pricing plan, so the travel mode could be separated to four patterns: (1)travel by car; (2)drive from home to the nearest railway station, park the car, then finish the trip by a train (P&R); (3)taking a bus to the nearest railway station and finish the trip by a train (Bus & Ride); (4) walk to railway station and take a train. All of the travel modes are showed as Pic.1.



Pic.1. Travel mode analysis

The parameters definitions and related parameter values are provided in Table.1and Table.2 below:

Tabel.1 Parameter definitions

Parameter	Symbol
Parking fees in city center	c_{pc}
Gasoline cost from city branch to city center	c_{gc}
Travel time from resident area to the city center by car	t_c
Time of traveler walk from home to the nearest bus stop	t_{wb}
Bus fare	c_b
Travel time from the nearest bus stop to the nearest railway station	t_b
Railway fare	c_r
Travel time from city branch to city center by railway	t_r
Travel time from home to the nearest railway station	t_p
Gasoline cost in this interval	c_{gp}
Parking fee in P&R parking lot	c_{pp}
Walking time from home to railway station	t_w

Cost of each travel mode is showed as below:

$$f_c = c_{pc} + c_{gc} + t_c \cdot \omega \quad (1)$$

$$f_b = t_{wb} + c_b + t_b \cdot \omega + c_r + t_r \cdot \omega \quad (2)$$

$$f_p = t_p \cdot \omega + c_{gp} + c_{pp} + c_r + t_r \cdot \omega \quad (3)$$

$$f_w = t_w \cdot \omega + c_r + t_r \cdot \omega \quad (4)$$

Where:f_c is the total cost of travel by car; $f_b$is same of travel by bus then transfer to train (bus & ride); $f_p$is same of travel by P&R; $f_w$is same of walk to railway station then take a train and ω is the value of time.

4. Calculation

To simplify the calculation, we simulated a linear city [2], which is shown as Pic.1, a railway connects city center and resident area, a congestible road is parallel to the railway, people live in the resident area randomly, and all trips are from home to the city center. Table.2 shows values of some related parameters.

Table 2 Related parameter values

parameter	value
Length between city center and resident area	10km
Railway fare	$y = 166.2 + 19.3x$, (Yen/km)
Parking fee	$y = 2.704 \times 10^4 e^{-3.246x} + 4146e^{2.799\times10-3x}$ (Yen · month/km)
Bus fare	$y = 109.4 + 28.1z$, (Yen/km)
Gasoline fee	9.855 Yen/km
Average speed of vehicle	35km/h
Average speed of walking	5km/h
Average speed of bus	15km/h
Average speed of train	60km/h

X: Length between city center and resident area;
Z: Bus driving distance.

Other prerequisites are provided as follows:

(1) There is one bus route running through resident area bound for railway station in city branch;

(2) Ignore waiting time of bus and train;

(3) Half of the residents have vehicle and have the possibility drive to work;
(4) Values of time (ω) are not same due to different income, Fig.1 shows time value distribution;
(5) Road between city center and resident area is parallel to railway, and congestible.

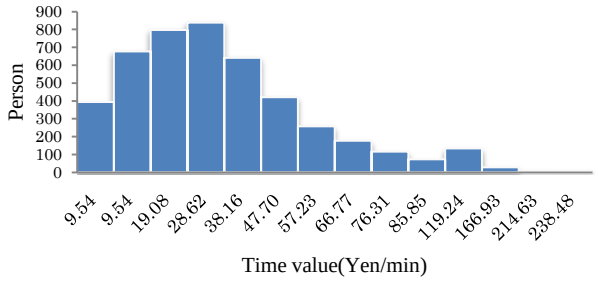


Fig.1 Time value distribution

5. Result

We took 714 samples as our calculating object, to find out the ratio of each travel pattern under different P&R price. Vehicle retainer and people who do not have cars are separated.

Before P&R introduced, as Fig.2 shows, in the car owner group, the ratio of bus utilizer is 2%.

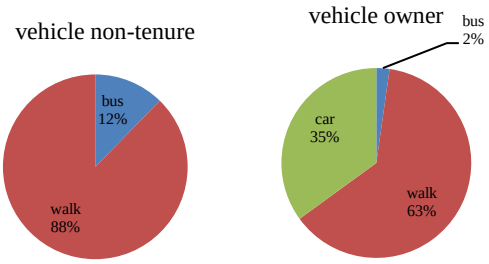


Fig.2Ratio of each travel mode before P&R introduced

After the introduction of P&R, the ratio of each travel pattern under existing value is showed as Fig.3, we can find with the introduction of P&R facility, car users are all change their way to travel.

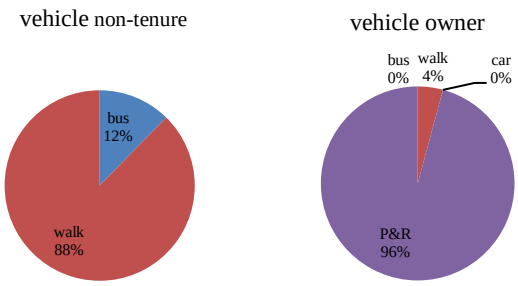


Fig.3Ratio of each travel mode under existing value

Let us focus on the vehicle owners only. Due to the introduction of P&R have absorbed trips from bus utilizers, so we need to find a P&R plan, which can make bus trips keep in an apposite level. We set several patterns, which price level and parking lot capacity is balanced. To raise the price of P&R, we try to find the maximum number of people who will use the P&R facility under this price level. Finally, we chose four patterns to show the change of travel mode under different P&R price level: (1)1556Yen/day, 149 users; (2) 2166 Yen/day, 100 users; (3) 2796 Yen/day, 50 users; (4) 3566 Yen/day, 20 users.Fig.4 shows ratio of each travel mode under different P&R price.

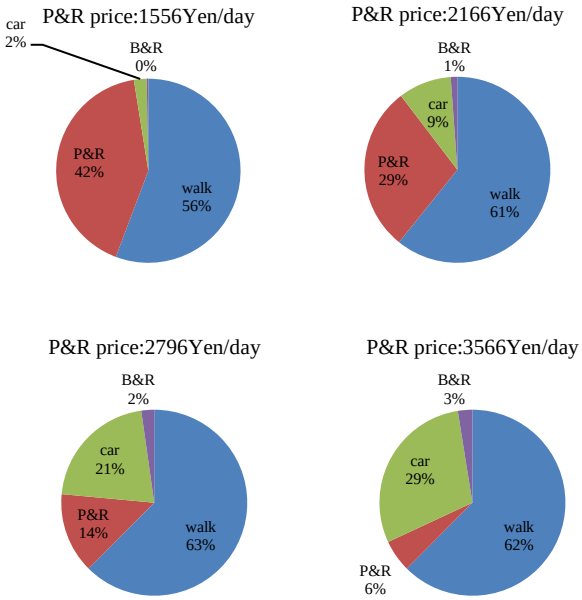


Fig.4Ratio of each travel mode after raising P&R price

6. Conclusion

From the calculation result, we can find under existing value, bus traffic is in a low level, except walking, people usually choose car to go to work. The introduction of a new travel mode—P&R, will occupy lots of traffic from other travel modes, we would like to see the traffic of car decrease, but since the introduction of P&R facility will impact on bus running, therefore lack of passenger will effect bus running condition. Through changing the price of P&R, we can realize the travel mode structure more effective. The new pricing plan of P&R can reduce car traffic and remain the bus trips to be in the same level as initial time.

Reference

[1] Michael R Cairns, The development of Park and Ride in Scotland, Journal of Transport Geography Vol.6,No4,pp.295-307,1997,

[2] Judith Y.T. Wang, Locating and pricing park-and-ride facilities in a linear monocentric city with deterministic mode choice, Transportation Research Part B 38 (2004) 709-731.