

The Effect of P&R Introduction on Bus Users and the Comprehensive Evaluation of Shared Use P&R

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**The Effect of P&R Introduction on Bus Users and the
Comprehensive Evaluation of Shared Use P&R**

By

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The Effect of P&R Introduction on Bus Users and the Comprehensive Evaluation of Shared Use P&R

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Chapter 1

Introduction

1.1 Background

Transportation Demand Management, or TDM, is a general term for strategies that increase overall system efficiency by encouraging a shift from single-occupant vehicle (SOV) trips to non-SOV modes, or shifting auto trips out of peak periods. This supports the Urban Mobility Plan's focus on moving people and goods rather than motor vehicles. TDM seeks to reduce auto trips – and hopefully vehicle miles traveled – by increasing travel options, by providing incentives and information to encourage and help individuals modify their travel behavior, or by reducing the physical need for travel through transportation-efficient land uses. The cumulative impact of a comprehensive set of TDM strategies can have a significant impact on travel behavior, system efficiency, and SOV rates. TDM programs are usually implemented by public agencies, employers, or via public-private partnerships.

P&R, as a method of TDM, is introduced to many countries in recent decades. Park-and-ride (P&R) facilities are car parks with connections to public transport that allow commuters and other people heading to city centers to leave their vehicles and transfer to a bus, rail system, or carpool for the remainder of the journey. The vehicle is stored in the car park during the day and retrieved when the owner returns. Park-and-rides are generally located in the suburbs of metropolitan areas or on the outer edges of large cities.

P&R facilities have been used since the 1930s as a travel demand management measure. P&R facilities have two roles: First, by facilitating modal shifts they allow travelers to drive where it is quick and convenient and to use public transportation where this is advantageous. Second, by encouraging people to take public transport for part of their trips, P&R facilities help alleviate traffic congestion and other adverse external effects of private vehicle travel. There is a relative paucity of research on the benefits and disadvantages of P&R schemes, which are often marketed as a way to avoid the difficulties and cost of parking in the city center, but it has also been suggested that there is a lack of clear-cut evidence for P&R's widely assumed impact on reducing congestion

In theory, P&R facilities allow commuters to avoid the stress of driving in a congested part of their journey and facing scarce, expensive city-center parking.

They are meant to avoid congestion by encouraging people to use public transport as opposed to their own personal vehicles. They do so by making it easier for people to use public transport in an urban area with traffic congestion, and often to reduce the availability of car parks to encourage this behavior.

P&R facilities serve the needs of commuters who live beyond practical walking distance from the railway station or bus stop which offers service to the city center.

P&R facilities may suit commuters with alternative fuel vehicles, which often have reduced range, since the facility may be closer to home than the ultimate destination. They also are useful as a fixed meeting place for those car sharing or carpooling or using kiss and ride (see below). Also, some transit operators use P&R facilities to encourage more efficient driving practices by reserving parking spaces for low-emission design, high-occupancy vehicles, or car sharing.

Most facilities provide services such as passenger waiting areas and toilets. Travel information, such as leaflets and posters, may be provided. At larger facilities, extra services such as a travel office, food shop, car wash, cafeteria, or other shops and services may be provided. These are often encouraged by municipal operators to increase the attraction of using park and ride.

However, British research suggests that the impact on congestion may be limited. Looking at both the UK policy background and evidence from an award-winning scheme in Cambridge, Jonathan Manns notes ‘an Hellerian 'Catch-22' situation, whereby the survival of local politicians is dependent upon its continuation, irrespective of its actual successes’. In Cambridge it is suggested that ‘there does not appear to be evidence of an overall drop in vehicle flow within the city’ and thus that ‘while cars parked at the P&R site are themselves no longer contributing towards the congestion externality, traffic flows are being generated elsewhere – for example, flows between car parks and homes from locals at whom the P&R was not targeted but who nevertheless are attempting to commute to the service. This is significant in that while certain cars are removed from the flow, new flows are stimulated net of other individuals, thereby significantly negating the overall impact of the service’.

In Sweden, a tax has been introduced on the benefit of free or inexpensive parking paid by an employer, in situations in which workers would otherwise have to pay. The tax has reduced the number of workers driving into the inner city, and increased the usage of P&R areas, especially in Stockholm. The introduction of a congestion tax in Stockholm has further increased the usage of park and ride.

In Prague, P&R car parks are established near some metro and railway stations (17 parks near 12 metro stations and 3 train stations, in 2011). These car parks offer

low prices and all-day and return (2× 75 min) tickets including the fare for the public transport system.

1.2 Objectives of the study

Based on the detailed information explained in chapter 2, it is known that there are some problems that need to be solved for P&R. P&R has been divided into two types: the traditional P&R and the new P&R such as shared use P&R.

For the traditional P&R, we notice that with the introduction of P&R facilities, it is attractive not only to car users but also to former public transport passengers. We focus on the effect of P&R introduction on bus users and try to find a method to maintain the stability of the number of bus users.

For the new type of P&R, we found that shared use P&R has been developed in some counties such as the US and Japan. It requires multi-party cooperation to develop the scheme, but the research on it is hard to find. In this paper, we tried to provide an approach to comprehensively evaluate potential shared use P&R.

1.3 Composition of dissertation

In this paper, we discuss how the P&R facility affects bus users and try to find a proper plan for the planners that decide the pricing and siting of P&R facility; and for the new type of P&R---- shared use P&R, we investigated the implementation of existing shared use P&R in Fukuoka, Japan and provide an approach to comprehensively evaluate potential shared use P&R.

Six chapters are included in this dissertation, the first chapter mainly introduces the concept of P&R facilities, and the research object ----- the effect of P&R facilities introduction on bus users and the approach to comprehensively evaluating potential shared use P&R are introduced.

The second chapter is literature review. We explained the previous research on P&R, the studies are mainly divided into four parts: the pricing and siting plan of P&R; the benefits of introducing P&R facilities; the traveler response to traffic modes; the implementation of P&R in various parts around the world and new type of P&R. Several problems which occur by the introduction of P&R facilities are discussed, from these problems we drew our research object ---- the effect of P&R introduction on bus users and the approach to comprehensively evaluating potential shared use P&R.

The third chapter is mainly talking about the effect of P&R introduction on bus users. We chose a residential area which is imaginary, using the existing data of Fukuoka city, Japan. The purpose of analyzing the travel modes is to simplify the calculation. By data analysis, we can get several conclusions which will affect the suggestion of the pricing and siting plan of P&R facilities.

The next chapter goes into the second issue: the research on shared use P&R. In this chapter, we investigated the implementation of existing shared use P&R in Fukuoka, Japan by review existing literature and feedback from local government.

The fifth chapter is the approach to comprehensively evaluating potential shared use P&R. In the previous chapter, we found some problems on the introduction of shared use P&R. In this chapter, we put our goal on comprehensive evaluation. We proposed a comprehensive evaluation standard and verified its feasibility through a case study.

The last chapter summarizes the research, and also points out several issues needing to be solved in future research.

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Chapter 2

Review of P&R

2.1 The origin of P&R

In order to solve the traffic congestion caused by car growth, P&R was proposed in the 1970s. P&R means that a commuter drives his own vehicle for a conveniently located parking area near a public transport facility, and then completes his journey to work by public transport. As a method of traffic demand management, P&R has developed in recent decades.

In the initial stage, the research of P&R was focusing on the feasibility and mathematical analysis. Elizabeth Cousins (1977) used a hypothetical circular city model to analyze the effect of the introduction of P&R on the travel time. There are limits of speed ratios and numbers of parking stations after which savings become negligible, and that dense concentrations of either homes or workplaces have a

marked effect on the savings. The use of and potential for P&R facilities on light rail transit system also have been discussed (Ian S. J. Dickins, 1991).

2.2 Development of P&R research

With the introduction of P&R by more countries, the research on P&R is divided into the following parts: the pricing and siting plan of P&R; the benefits of the introduction of P&R; the traveler response to traffic modes; P&R implementation in various parts around the world.

2.2.1 The pricing and siting plan of P&R

Judith Y. T. Wang investigates the optimal location and pricing of a P&R facility in a linear city. Residences are uniformly distributed from the center to the exogenous city boundary, and all trips are from home to the center. A congestible highway and a congestion-free railway can be accessed at all points along the travel corridor. Deterministic mode choice equilibria are characterized before and after a P&R service is introduced. Profit maximizing and social cost minimizing P&R locations and parking charges are then derived and compared. A numerical example illustrates the possibility of a 'win-win' situation whereby a P&R facility can be profitable, as well as socially beneficial by reducing total travel costs. Ge Gao also conducted a multimodal analysis in a competitive railway system along a linear

monocentric city. A price-based tradable credits scheme is introduced into the P&R design in which the credit price is determined by the government. Based in linear monocentric city there are more studies on P&R planning (Tian-Liang Liu, 2009; Bo Du, 2014).

Bilal Farhan investigates the location problem of P&R using a multi-objective spatial optimization model. There are three major siting/modeling concerns that need to be addressed when siting P&R facilities: covering as much potential demand as possible, locating P&R facilities as close as possible on major roadways, and siting such facilities in the context of an existing system. To simultaneously address each of these concerns, a multi-objective spatial optimization model is provided. This model is applied for siting P&R facilities in Columbus, Ohio, and the results show the usefulness of the developed model in supporting transit planning in an urban region. On the other hand, a mixed linear programming formulation to determine the location of a fixed number of P&R facilities which make their usage maximal is proposed (Felipe Aros-Vera, 2013). In addition, the network flow-based strategies for identifying rail P&R facility locations were discussed (Mark W. Hornera, 2007) and the optimal P&R location under potential demand maximization was developed (José Holguin-Veras, 2012).

In terms of the integrated planning of P&R facilities, a comprehensive approach to comprehensively evaluating potential P&R facilities is developed which

provides a step-by-step methodology to analyze the attractiveness of a P&R (Lorenzo Cornejo,2014); moreover, an integrated planning framework to locate P&R facilities and optimize their capacities as well as transit service frequencies simultaneously is proposed (Ziqi Song, 2017; Cristobal Pineda, 2017).

Mark W. Horner developed a flexible GIS-based methodology for evaluating the potential locations of terminal P&R facilities along urban rail lines. The methodology differs from politics-based approaches and traditional travel demand modeling in its use of an objective measure of accessibility to gage the suitability of a site.

Compared with the locations of P&R, there is not much research of pricing policies in P&R facilities. Optimal pricing schemes for a parking facility using a financial analysis model were developed, the model can offer nearly optimal pricing schemes in a short amount of time (Kepaptsoglou Konstantinos, 2010), and a doubly dynamics for multi-modal networks with P&R and adaptive pricing was provided (Wei Liu, 2017).

Some studies also notice the relationship between air pollution and P&R price, a Markov decision process has been devised to find an optimal policy for pricing the P&R facilities and cordon entry in a city within a variable demand context. (H. Poorzahedy, 2016)

2.2.2 The benefits of the introduction of P&R

Some studies on P&R focus on the benefits, and whether P&R facilities are effective in reducing traffic congestion.

Michael R Cairns stated that the provision of P&R services is one of the principal means of addressing problems caused by traffic congestion in urban areas. Bus-based P&R schemes are intended to attract motorists from outside an urban area to park at a peripherally located car park and travel by bus to the town center. A number of local authorities in Scotland have been developing such schemes. These will introduce a new form of land use on the fringe of Scotland's towns and cities. In addition, the provision of P&R is also likely to influence the catchment areas of retail and tourist centers and the residential location of employees in towns thus served.

The impact of the P&R strategy on emissions is discussed. A case study in Shanghai using the sketch planning method investigated that the P&R facility has played an important role in reducing emissions (Hongcheng Gan, 2013), Europe also has the same issue (Marc Dijk, 2013) and Rikhotso's research also confirmed this point of view.

2.2.3 The traveler response to traffic modes

As the number of users of P&R increases, traveler response to traffic modes is a big issue to P&R research. It can not only clarify the travel choice behavior but also predict the user of P&R facility.

Hao Pang focused on commuters' P&R location choice decisions. A thorough analysis on the choice set generation was conducted, and two criteria were used to determine the most appropriate P&R choice set for each observed trip. User heterogeneity was accounted by adding interaction terms in the utility functions and by using mixed logit models. The study implies that non-Caucasians prefer higher fraction of their auto path on freeways; and commuters with higher income are less motivated by high transit service frequency.

The accessibility impacts for first/last mile transport connectivity to/from the major transit line were analyzed, which can evaluate the transit services (Shailesh Chandra, 2013).

Many previous studies have investigated the decision behavior (Ame Risa Hole, 2004; Huanmei Qin, 2013; Clayton, 2014; Xing Zhao, 2017; Eleonora Sottile, 2017). The difference between P&R and kiss and ride station choices was also

examined (AHM Mehbub Anwar, 2017).

In terms of the P&R lot choice, parking lot choice behavior was analyzed. A choice model was used to help users choose a best train station which can save travel cost and time of the P&R users (Zhirong Chen, 2014; Bibhuti Sharamal, 2017).

2.2.4 The implementation of P&R in variety parts around the world

P&R is introduced in many countries and the studies of local P&R scheme are discussed. Table 2-1 briefly introduces the relevant research of P&R in various countries.

In the US, the P&R provision at light rail stations was analyzed (Michael Duncan, 2013).

In Europe, a study focuses on the policy frames of P&R in Europe, a survey is taken in 45 major cities in Europe, and it is found that organizational learning capabilities are the most important drivers for city governments whether or not to engage in P&R development, explaining 40% of the variance in their actual engagement in P&R deployment (Marc Dijk, 2011). Moreover, the developmental analysis of P&R facilities in Vilnius (V. Palevičius, 2015), the mobility-transformative qualities of urban P&R policies in the UK and Netherlands

(Marc Dijk, 2014), stakeholder perspectives on the current and future roles of UK bus-based P&R (Stuart Meek, 2009) and the local authority attitude to P&R in UK (Stuart Meek, 2010) are also reported. A case study was conducted to enhance the P&R with access control in Southampton, UK (Nick Hounsell, 2011). In Netherland, transport and environmental effects of P&R were discussed. The study investigated that the introduction of a fee for parking would reduce the unintended effects (Giuliano Mingardo, 2013).

In Singapore, the experiences of P&R scheme were reported, using the survey of P&R users, it is found that cost savings are a major incentive for participating in the P&R scheme (Foo Tuan Seik, 1997). In other countries in Asia, parking demand and the utilization patterns of P&R were discussed in Malaysia (Phooi Wai Ho, 2017; Norlida Abdul Hamid, 2009). China conducted a survey to investigate the attitude and preference of traveler to the P&R facilities (Baohong Hea, 2012). In Japan, many social experiments on P&R have been implemented. Using duration model to analyze the attention behavior to P&R scheme has been researched (Akimasa Fujiwara, 1997). For the policy making and evaluation, a P&R social experiment through workshop was conducted (Itsuki Shirakawa, 2002).

In Australia, the utilization of P&R lots in South East Queensland was developed and the result suggested that most of the P&R lots are filled or reach a steady arrival pattern by 9:30 am (Bibhuti Sharma, 2016). Travelers' attitudes towards

P&R choice were reported (Doina Olarua, 2014), moreover, the enhanced Huff model for estimating P&R catchment areas in Perth was developed (Ting Lin, 2016).

Table 2- 1 P&R researches in various countries

Area	Country	Study Object
America	America	P&R Provision
Europe	UK	P&R policy
		Stakeholder perspectives on P&R
		Local authority attitude to P&R
		Enhance the P&R
	Netherland	P&R development
		Transport and environmental effects of P&R
	Lithuania	Developmental analysis of P&R
Asia	Singapore	Experiences of P&R scheme
	Malaysia	Parking demand and the utilization patterns of P&R
	China	The attitude and preference of traveler to the P&R
	Japan	Attention behavior to P&R
		P&R policy
Oceania	Australia	The utilization of P&R lots
		Travelers' attitudes towards P&R
		P&R catchment areas estimation

2.2.5 New type of P&R

In a report conducted for Urban Land Institute by Barton Associates in America, in 1983, shared use P&R is defined as P&R spaces that can be used to serve two or more individual land uses without conflict or encroachment. The authors note that shared use P&R only works with developments that meet certain conditions:

- When there are variations in the peak accumulation of parked cars, due to the time differences inherent in the activity patterns of adjacent or mixed land uses.
- When the land uses are so related that people are attracted to two or more of them on a single auto trip to the development or area such as shopping and dining at the same complex.

With the increase of electric vehicles, an electric vehicle (EV) park-charge-ride (PCR) program was proposed. The study found that an EV PCR commuter can reduce up to 87% of personal VMT and 52% of carbon emissions (Ning Ai, 2018).

2.3 Problems of P&R facilities

Though much research proved the P&R facilities have effectiveness in reducing congestion in city center, there are still many problems existing during the

operation of the P&R facilities.

2.3.1 Car trips increase in suburb areas

G. Parkhurst found that the rate of provision of bus-based P&R facilities on the fringes of UK urban areas has grown in recent years. However, there has been a debate about whether the schemes reduce traffic. Research published in 1998 for the UK Government considered eight case studies and was interpreted by some as providing reassurance that P&R can have traffic-reduction benefits. The present paper offers a new approach to the appraisal of the same eight P&R schemes, separating the analysis into urban and extra-urban components. The urban-area analysis considers the net result of intercepting cars on the edge of urban areas and running additional dedicated bus services from the car parks. The finding is that traffic was avoided in seven out of eight cases. The analysis of the extra-urban effects of P&R considers three sources of traffic increase: motorists that are intercepted detouring to reach sites, users switching from public transport services and motorists making additional trips. All are found to be important phenomena, with the total additional traffic generated outside the urban area being greater than that avoided within the urban area in every case study. It is concluded that the main effect of the scheme is traffic redistribution, and that their role within traffic restraint policies is unlikely to be directly one of traffic reduction.

2.3.2 The effect on bus users

Graham Parkhurst found that the detailed and long-term effects of P&R are more complex than generally acknowledged. In 1994, studies of P&R were carried out in Oxford and York. The success of P&R in attracting users was confirmed, and these users reported high levels of satisfaction. However, some users had switched from modes other than car and others were found to be making additional trips which had been attracted by the opportunity to P&R. Congestion has remained persistent in the cities studied and there is concern that total travel may have been increased rather than reduced, which was the intention. It is concluded that, for P&R to be successful, 'package' policies will need to be strengthened to favor conventional public transport and that particular care will need to be taken by other local authorities adopting P&R.

2.3.3 Shared use P&R problem

Shared use P&R has been implemented in many parts of the United States, but research on it is little. Similar facilities have emerged in Japan, and operators have not seen it as a type of P&R. In terms of implementation, unlike traditional P&R, it is necessary to establish a cooperative relationship with the existing parking lot operators, and the problems generated under this new mode have not received

enough attention.

2.4 Summaries

This chapter reviews P&R-related research. Early P&R research focused on feasibility studies and mathematical analysis. With the popularity of P&R, research on P&R is more diverse. This chapter discusses P&R's location selection and pricing issues, traveler response to traffic mode after the P&R is introduced, the benefit of P&R, and P&R implementation in different countries. Finally, it tells the current problems of P&R, mainly whether the car trips increase in suburb areas after the P&R is introduced, the effect on bus users and the implementation of new type of P&R. In view of the above problems, this paper selects two of them for discussion. For the traditional P&R, we discussed the effect of P&R introduction on bus users; for the new type of P&R, we have selected shared use P&R as our research object and studied the comprehensive evaluation approach to potential shared use P&R.

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Chapter 3

Research on the effect of P&R facility introduction to bus users

3.1 Introduction

Park-and-ride (P&R) facilities are car parks with connections to public transport that allow commuters and other people to head to the city centers to leave their vehicles and transfer to a bus, rail system, or carpool for the remainder of the

journey. The vehicle is stored in the car park during the day and retrieved when the owner returns. Park-and-rides are generally located in the suburbs of metropolitan areas or on the outer edges of large cities.

Park-and-ride facilities serve the needs of commuters who live beyond practical walking distance from the railway station or bus stop which offers service to the city center. Park-and-ride facilities may suit for commuters with alternative fuel vehicles, which often have reduced range, since the facility may be closer to home than the ultimate destination. They also are useful as a fixed meeting place for those car sharing or carpooling or using kiss and ride (see below). Also, some transit operators use park-and-ride facilities to encourage more efficient driving practices by reserving parking spaces for low emission designs, high-occupancy vehicles, or car sharing. Most facilities provide services such as passenger waiting areas and toilets. Travel information, such as leaflets and posters, may be provided. At larger facilities, extra services such as a travel office, food shop, car wash, cafeteria, or other shops and services may be provided. These are often encouraged by municipal operators to improve the attraction of using park and ride.

As we mentioned in last chapter, though many researches have proved that the P&R facilities are effective in reducing congestion in city center, there are still many problems exist during the operation of the P&R facilities. G. Parkhurst found that the rate of provision of bus-based park and ride facilities on the fringes of UK

urban areas have grown in recent years which leads to a reduction of the bus use in residential areas. But there is no further research focus on this issue.

Therefore, in this chapter, we provide a P&R facility siting and pricing plan which will attract car drivers to change their travel mode to public transportation and keep the bus operation in a hypothesis linear city.

3.2 Residence area modeling and travel mode analysis

3.2.1 Residence area modeling

3.2.1.1 Assumption

In this research, we mainly talk about the effect of P&R construction on bus users, so first we need to set a model which only focuses on the residents travel mode to analyze the change of travel behavior before the introduction of P&R and after.

There are many factors need to consider if the objective city is an existing one, some will influence the result of the calculation, therefore we set a supposed city to simplify the calculation.

There are several required assumptions:

1. Residents in the suburb area are random distribution;
2. Waiting time of bus and train is included in travel time;
3. Car ownership rate in this area is 50%;
4. Road between city center and residential area is parallel to railway, and congestible;
5. Residents' travel mode choices only depended on total general cost, that means, people only choose the travel mode of minimum cost, ignoring the individual preference;
6. Ignoring the distance between P&R parking lot and the railway station;
7. Ignoring the capacity of P&R parking lot;
8. All speed used in this research is average speed and changeless, that means, the level of congestion in road is the same in any random section;
9. Parking fee is monthly paid;
10. Purpose of all the trips is commuting;
11. There are 20 working days per month;
12. Ignoring travel by bikes and motorbikes.

3.2.1.2 Modeling

The image of the residential area is shown in Fig.3-1. Taking the railway station in suburb area as the center of the circle; people live in a 3kilometer-radius-circle randomly. The railway station covered area is a 1kilometer-radius-circle and the center is the railway station, residents who can walk to the railway station are all live in this area. There are two bus routes running through the residential area heading to the railway station. Road connecting city center and suburb area is parallel with the railway and congestible. There are three methods for residents live in the target area to access this road.

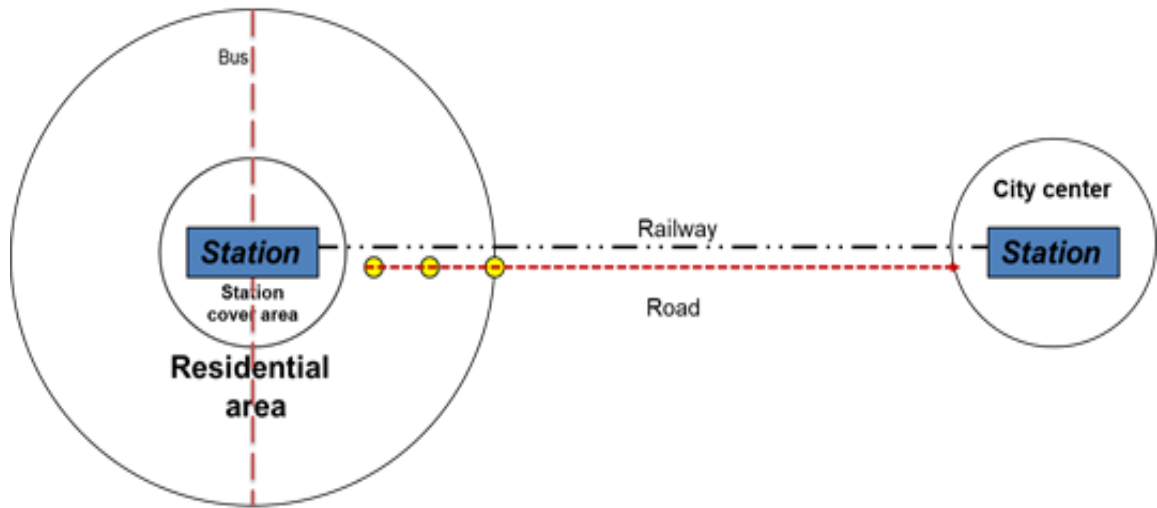


Fig.3 - 1 Residential area model

3.2.2 Travel mode analysis

Since the research object is the effect of P&R facilities on bus users, we focus on the travel modes related to P&R facility and bus. There are four travel modes we need to consider: traveling by car; traveling by bus then transfer to train to the city center; park-and-ride; walking to the railway station then taking a train to the city center.

The reason why we take the walk pattern into our research is that the residents are randomly distributed and some of them live very close to the railway station. As walking is a very common measure for travel, it is necessary for us to put the walking pattern into the travel mode analysis. On the other hand, it is impossible for all residents to walk from home to the railway station because the railway station has a cover area, people who live in the cover area have the possibility to go to the railway station, while other people will have a low motivation to choose this travel mode. Referring to the data from MLIT (Japanese Ministry of Land, Infrastructure, Transport and Tourism), the cover area of a railway station in Japan is a 1kilometer-radius-circle and the center of the circle is the railway station.

3.2.2.1 Traveling by car

Traveling by car is a very simple travel mode. People live in the suburb area would drive a car to the city center, then park the car in the parking lot near the destination in the city center. When they get off work, they pick the car from the parking lot in the city center then drive to the suburb area. Fig. 3-2 shows the image of the mode of travel by car.

The cost of the mode of travel by car is constituted in two parts: every kind of expenses, such as, the gasoline fee, the parking fee, etc; the other cost is the time value—time cost in traveling, which can be translated into money.

In travel by car pattern, the general cost includes:

1. Parking fee in the parking lot of city center (c_{pc});
2. Gasoline cost during the trip between residential area to the city center by car (c_{pg});
3. Time cost during the trip from residential area heading to the city center by car (t_c).

The total general cost of the pattern travel by car therefore:

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

Where: f_c is the total cost of travel by car; ω is the value of time.

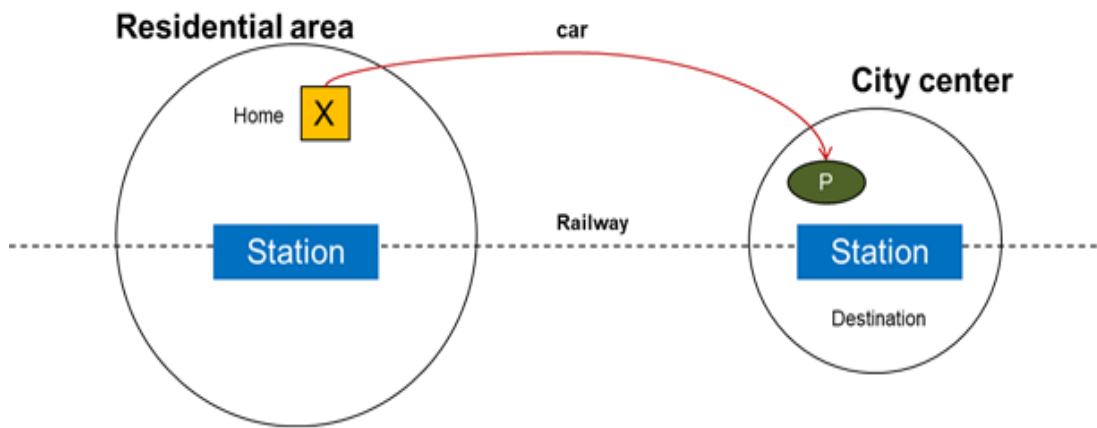


Fig.3- 2 Traveling by car

3.2.2.2 Walking to the railway station then taking a train

For this travel pattern, people walk from home to the nearest railway station, then take a train to finish the trip. As we mentioned in the beginning of the chapter, this travel mode has some requirements for the range of the place where residents live. The cover area is a 1kilometer-radius-circle, so people who live in this circle can walk to the railway station and no residents choose the same travel mode live in the

outer place of the circle. Fig. 3-3 shows the image of the mode of walk to the railway station then taking a train.

Same as that of the mode of travel by car, the total general cost of the mode of walking to the railway station then taking a train also includes the expenses and the time value. This travel pattern is a little complicated than the mode of travelling by a car, so the cost therefore:

1. The cost of railway ticket (c_r);
2. Time of walking from home to the nearest railway station (t_w);
3. Time of taking a train from suburb area to the city center (t_r).

The total general cost of this mode is shown as follow:

$$f_w = t_w \cdot \omega + c_r + t_r \cdot \omega \quad (2)$$

Where: f_w is the total general cost of walking to the railway station then taking a train; ω is the value of time.

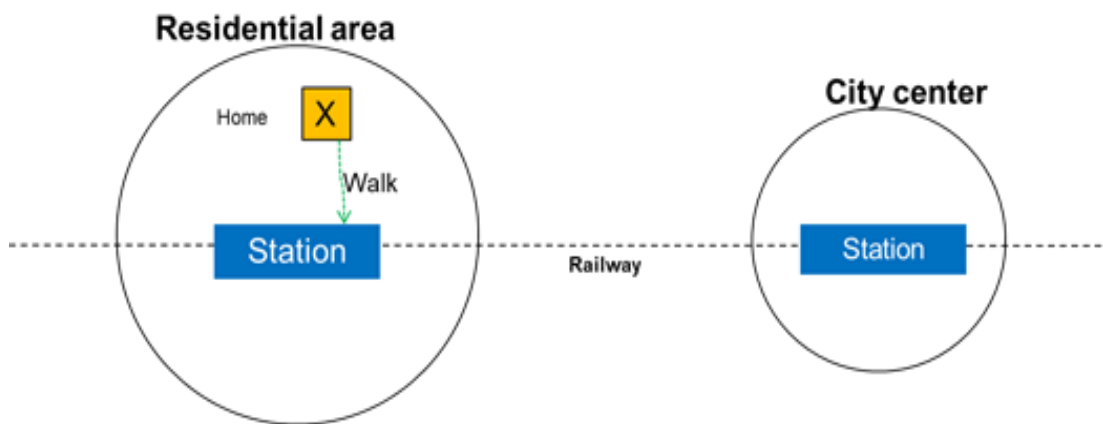


Fig.3- 3 Walking to the railway station then taking a train

3.2.2.3 Taking a bus to railway station then transfer by a train

Taking a bus to the railway station then transferring by a train is the most complicated mode in all the four travel modes, it can be separated into many small trips; and it is made by many kinds of travel modes.

The mode of taking a bus to the railway station then transferring by a train includes three kinds of transportations: walking, taking bus and train. First, resident

walk to the nearest bus stop, then take a bus to the railway station located in the suburb area; transfer by a train to go to the city center, and then finish the whole trip.

The image of the mode of taking a bus to railway station then transferring by a train shows as Fig. 3-4.

As the mode of taking a bus to the railway station then transferring by a train is complicated, the general cost of this travel mode is also made by many kinds of expenses:

1. The cost of bus fare (c_b);
2. The cost of train ticket (c_r);
3. Time of walking from home to the nearest bus stop (t_{wb});
4. Time of taking a bus from the nearest bus stop to the railway station located in the suburb area (t_b);
5. Time of taking a train from the railway station in the suburb area to the city center (t_r).

The total general cost of this mode is shown as follow:

$$f_b = t_{wb} \cdot \omega + c_b + t_b \cdot \omega + c_r + t_r \cdot \omega \quad (3)$$

Where, f_b is the total general cost of taking a bus to the railway station then transferring by a train, and ω is the value of time.

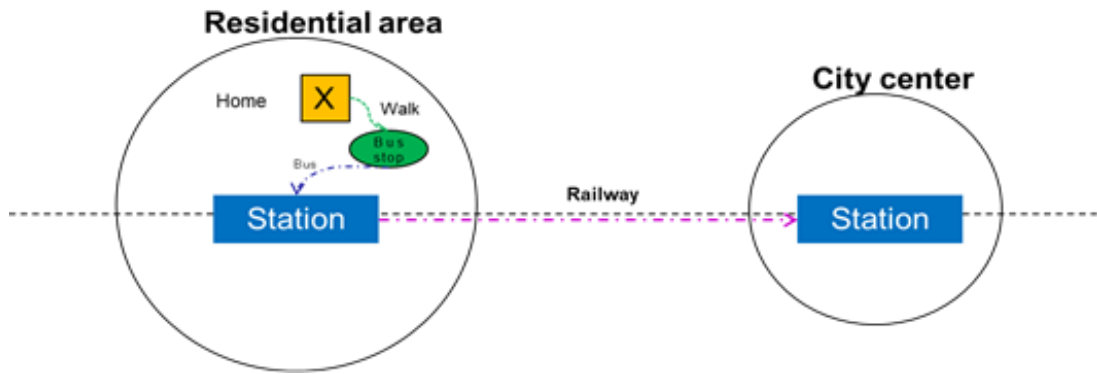


Fig.3- 4 Taking bus to the railway station then transfer by a train

3.2.2.4 P&R

For the travel mode of P&R, there are two parts of travel behaviors: driving a car from home to the P&R parking lot near the railway station and parking the car, taking a train to the city center and finishing the trip. Fig. 3-5 shows the image of the travel mode of P&R.

The total general cost of the travel mode of P&R includes a lot:

1. The gasoline cost from home to the nearest railway station in the suburb area by car (c_{gp});
2. Parking fee of the P&R parking lot (c_{pp});
3. The cost of train ticket (c_r);
4. Time cost from home to the nearest railway station in the suburb area by car (t_p);
5. Time cost from the railway station in the suburb area to city center by taking a train (t_r).

And the total general cost therefore:

$$f_p = t_p \cdot \omega + c_{gp} + c_{pp} + c_r + t_r \cdot \omega \quad (4)$$

Where, f_p is the total general cost of the travel mode of P&R; ω is the value of time.

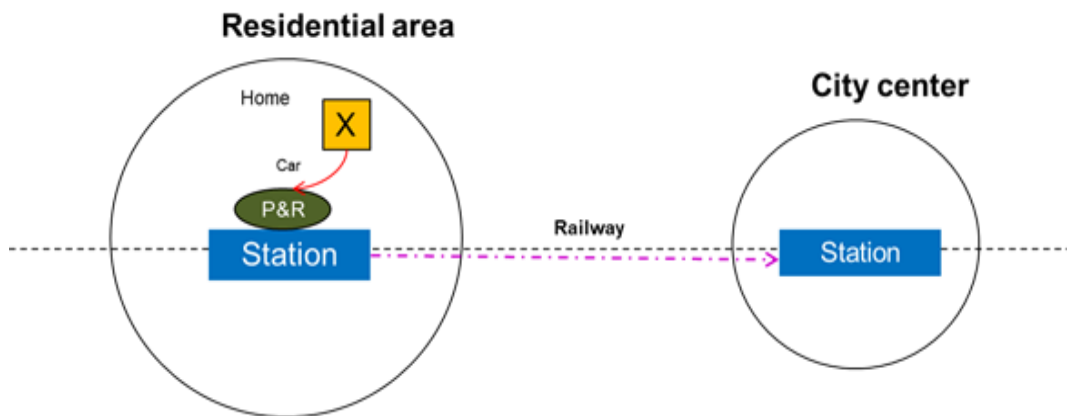


Fig.3- 5 P&R

3.2.3 Resident distribution

Since the residential area is a 3kilometer-radius-circle, we take the population density of Fukuoka City (4,564person/km²) into calculation and the number of residents in the target area is 714. Due to assumption 1, all the residents are randomly distributed in the residential area. Fig. 3-6 shows the location where each resident lives.

The estimation of the effect of the P&R facilities introduction to bus users issue is related to the equations given in the previous sections. Since the number of residents is comparatively big, we use FORTRAN to program the whole calculation.

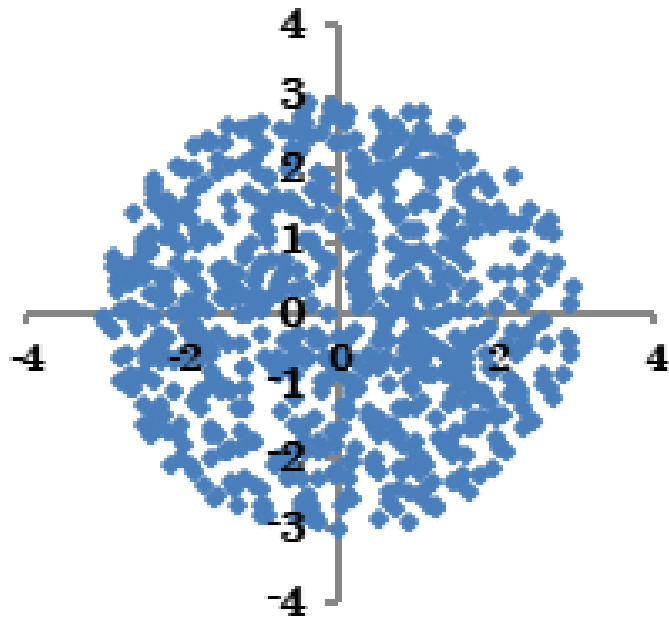


Fig.3- 6 Resident distribution

3.3.1 Individual Variability

Before the calculation, there are two individual variability need to be announced, the variability of time value and the variability of vehicle ownership.

3.3.1.1 Variability of time value

Since the income of each resident is different, the value of time is also different.

The formula of the value of time given by MLIT is shown as follow:

$$\text{Time value} = \frac{\text{Average monthly total income(Yen)}}{\text{Average monthly working time(min)}} \quad (5)$$

From the equation we can find that the value of time is related to income and total working time. Suppose that working time of the residents who live in the target area is the same, the decisive factor of the variability of time value is the total income. Referencing the private income survey carried out in 2011, the distribution of the revenue total income of Japan is shown as Fig. 3-7:

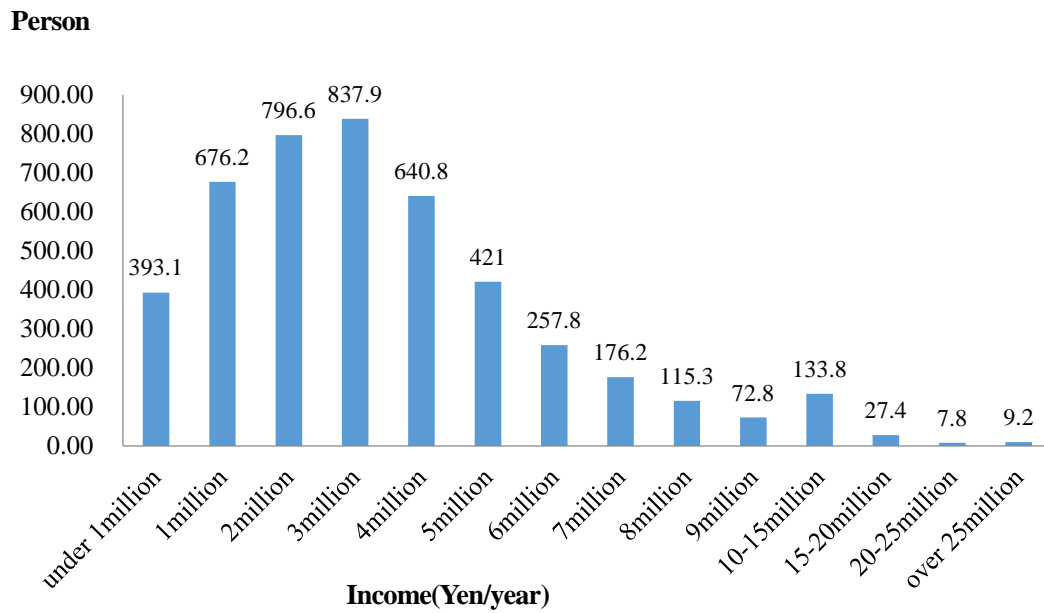


Fig.3- 7 Revenue income distribution

From Fig. 3-7 we can find that most people's revenue incomes are imploded in the 1-5 million Yen ranges. Other distribution ranges are also in the level which cannot be neglected. So using the equation (5), we can get the distribution of time value in different incomes. Fig. 3-8 shows the distribution of the value of time.

Using the distribution of each value of time, we can get the variability on value of

time.

Person

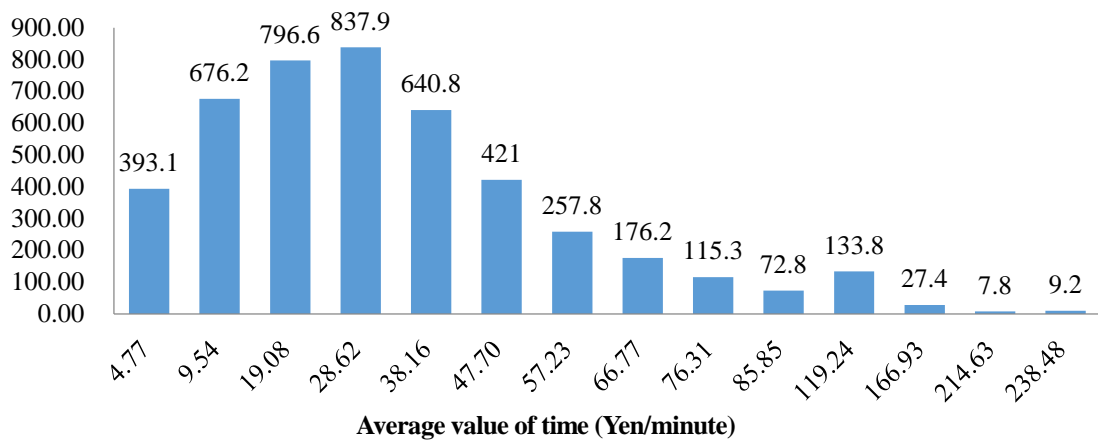


Fig.3- 8 Value of time distribution

3.3.1.2 Variability of vehicle ownership

In reality, it is impossible for every person to have a vehicle in a random residential area. In our research, it is necessary to bring the concept of vehicle ownership in our calculation. From the North Kyushu Person Trip Survey occurred

in 2005, Fig. 3-9 shows the vehicle ownership of each age in Fukuoka city. And the distribution of the employment of each age is shown by Fig. 3-10.

Using the percentage of the employment in different ages and the distribution of the vehicle ownership, we concluded the vehicle ownership rate in Fukuoka City is 50%. The data is also applicable in our calculation.

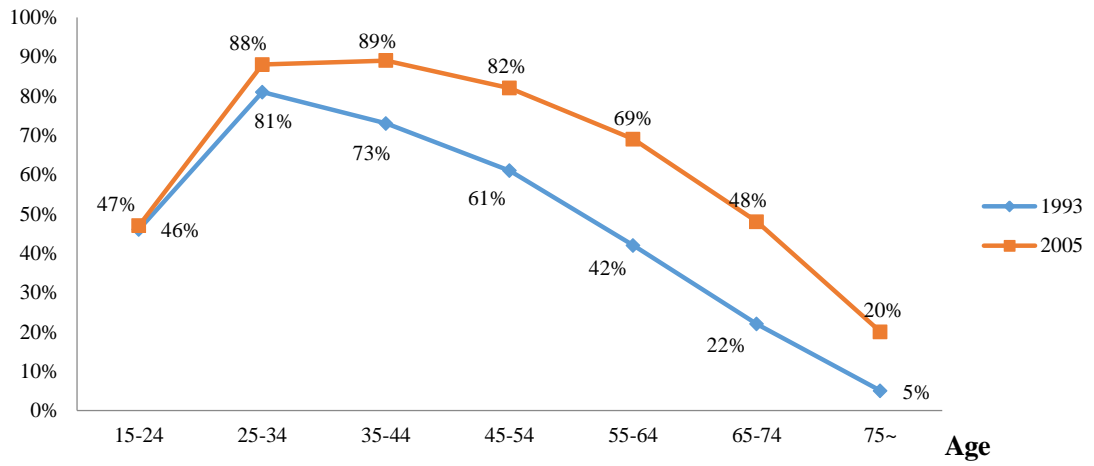


Fig.3- 9 Vehicle ownership in Fukuoka City

person

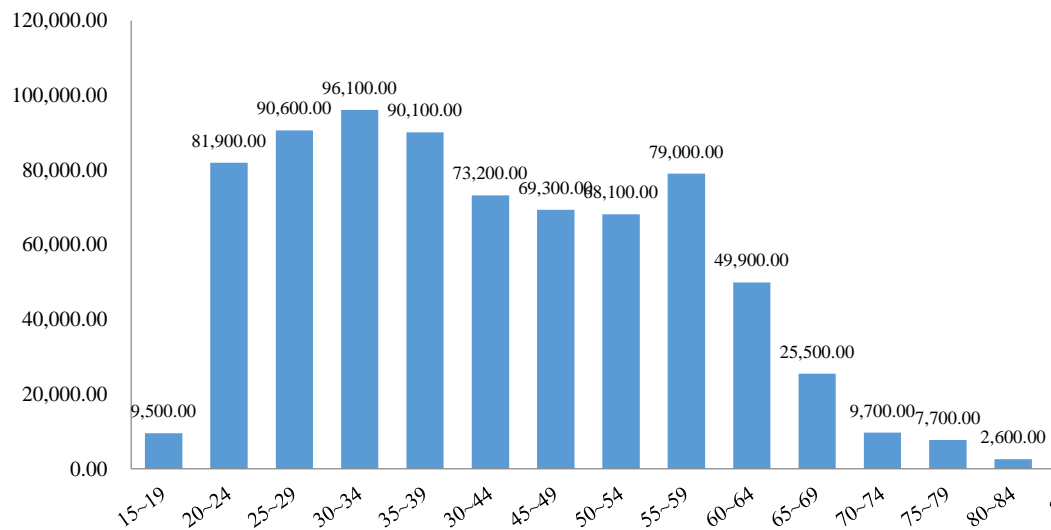


Fig.3- 10 Employment Distribution of Fukuoka City

3.3.2 Parameters

The related parameters in the calculation are referenced by the data of Fukuoka City and MLIT. Some of the parameters do not have the existing data, so we need to obtain them from some related data at first.

3.3.2.1 Parking fee

There is no existing formula about parking fee, so we need to find some information or data related to the parking fee issue. First we investigated parking lots in Fukuoka City, and recorded the price of parking fee in city center and in suburb area. The distance between parking lot and the city center also need to be recorded. Using the data collected, we can draw a distance-price curve by Matlab. The curve is shown by Fig. 3-11.

By analyzing the approximation curve in Fig.3-11, we can conclude the relationship between distance from city center and monthly parking fee therefore:

$$y = 2.704 \times 10^4 e^{-3.246x} + 4146e^{2.799 \times 10^{-3}x} \quad (6)$$

(Correlation coefficient =0.88)

Where: x is the distance between the parking lot and city center (km); y is the monthly parking fee (Yen/Month).

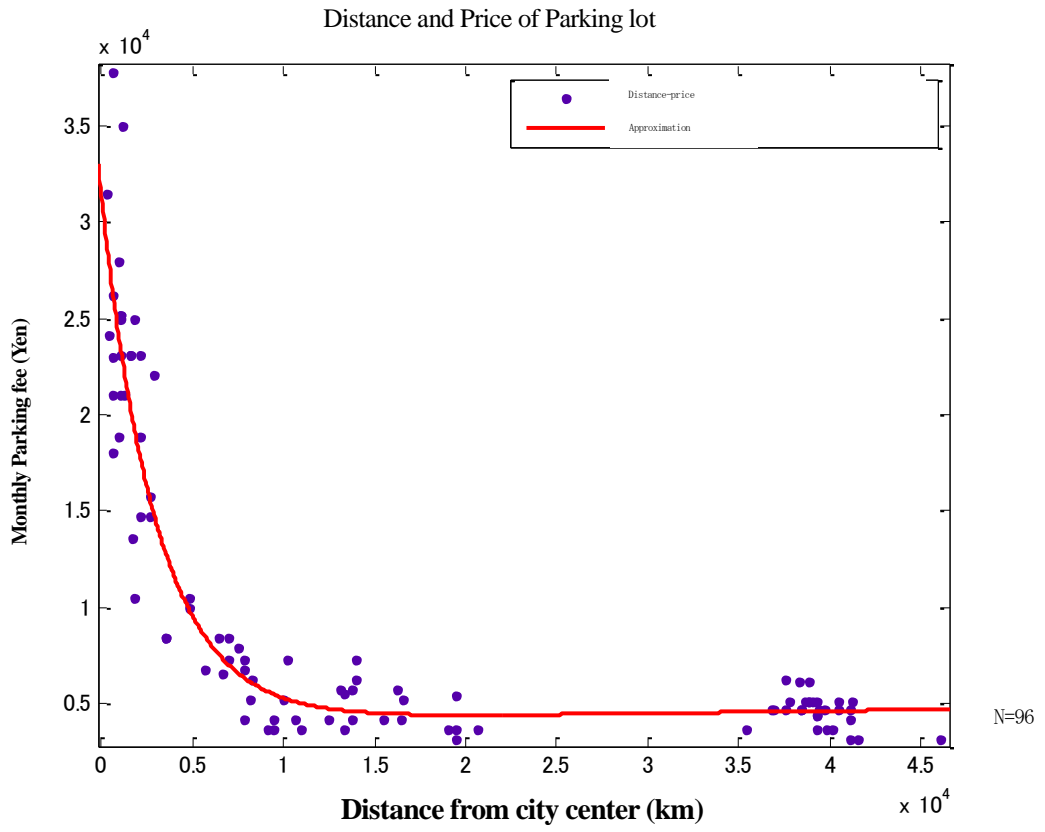


Fig.3- 11 Distance and Price of Parking lot

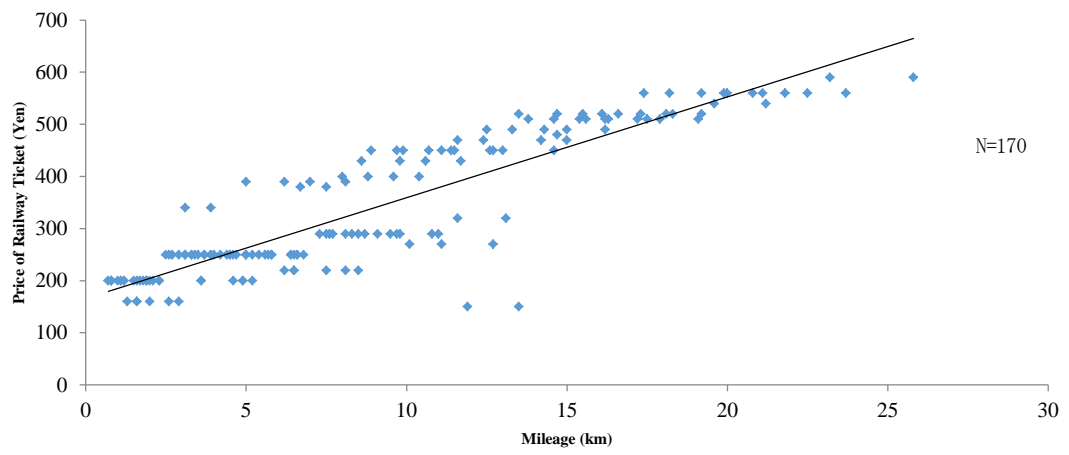
3.3.2.2 Price of railway ticket

The data of railway ticket price is an important parameter in our research. We seek the data from Kyushu Railway Company, and collect the charges of the lines running in Fukuoka City. By analyzing the price of railway ticket and mileage, we can get a linear relationship between them. Fig. 3-12 shows the relationship between mileage and price of railway ticket.

And the equation of the relationship therefore:

$$y = 166.2 + 19.3x \quad (\text{Correlation coefficient}=0.80) \quad (7)$$

Where: x is the mileage the train running (km); y is the price of railway ticket (Yen).



3.3.2.3 Price of Bus fare

Since most of the data we quoted are from Fukuoka City, the price of bus fare we collected also came from Fukuoka City. As the biggest bus company in Fukuoka City, Nishitestu Bus Company running a big amount of bus routes which running through most area in Fukuoka City. By collecting the mileage and the existing price of bus fare, we can get a relationship between them. Fig. 3-13 shows mileage and the price of bus fare.

The equation of the relationship between mileage and price of bus fare therefore:

$$y = 109.4 + 28.1x \quad (\text{Correlation coefficient} = 0.94) \quad (8)$$

Where: x is the mileage the bus running (km); y is the price of bus fare (Yen).

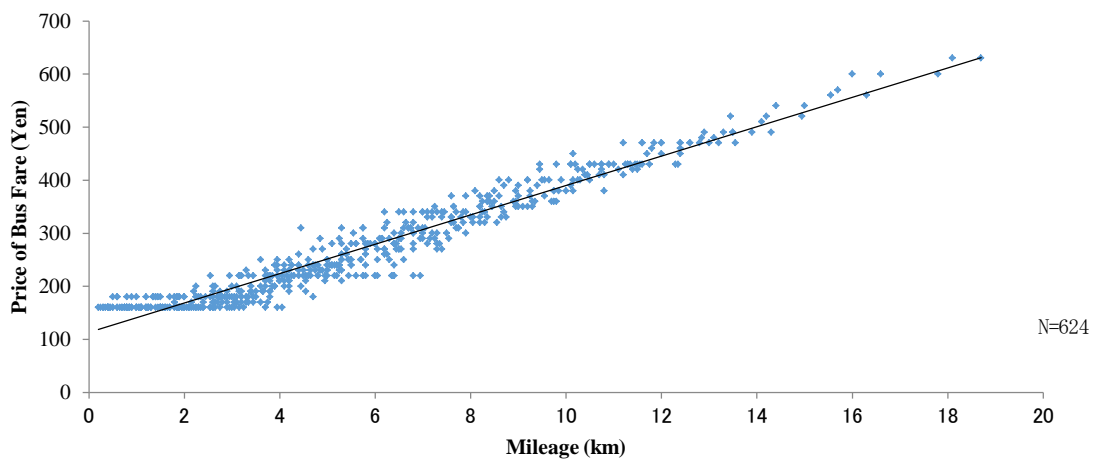


Fig.3- 13 Mileage and Price of Bus Fare

3.3.2.4 Other parameters

Except the parameters mentioned in the last sections, there are some other parameters related to the calculation.

As we mentioned in last section, all the speed related with the research are changeless, so we selected the average speed for the calculation. Calculating the existing running speed of public transport, collecting walking speed and vehicle speed in rush hours, Table 3-1 shows all the speed related.

Table 3- 1 Related speed values

Parameter	Value
Average speed of vehicle	35km/h
Average speed of walking	5km/h
Average speed of bus	15km/h
Average speed of train	60km/h

Except speed, there is an important parameter related to the cost of using cars—the gasoline fee. Referencing the data given by MLIT, the value of gasoline fee is 9.855Yen/km (2014).

3.3.3 Estimation

To investigate how the distance effects on the price of parking fee, the calculation has been separated into two patterns since we chose two residential areas and the distance to city center are 10 kilometers and 20 kilometers separately. On the other hand, half of the residents live in the target area do not have a car, so their travel behavior will not be affected by the introduction of P&R facilities. Therefore, the non-vehicle residents and vehicle holders should be calculated separately.

3.3.3.1 Non-vehicle residents

For the residents who do not have a car, the only travel modes they can choose to the nearest railway station are walking then taking a train or taking a bus to the nearest railway station then transferring to a train. The total number of samples is 714 and the number of non-vehicle residents is 357.

People who can walk to the railway station—as mentioned in section 3.2, are all living in the railway station cover area. It is a 1kilometer-radius-circle of which the center is the railway station. Therefore, we can get the number of residents who live in this area, and using the vehicle ownership rate, we can find that the number of residents who can choose this travel mode is 53. That means, 53 residents live in the railway station cover area, without having a vehicle, have a potential to choose

the mode of walk to the railway station and take a train to go to city center.

3.3.3.2 Vehicle holders

For the residents who have a vehicle, they can choose all the travel modes mentioned in section 3.2. There are also some people who have the possibility to choose the mode of walking to the railway station then taking a train to the city center, and the number of the residents is 32.

3.3.4 Method of estimation

It is possible to program all the estimation procedures. The method of estimation is to calculate the cost of each sample in four travel modes using the equations (1), (2), (3), (4) mentioned in section 3.2, by comparing the cost we can find the minimum cost among four travel modes. Using the results of the estimation, it is easy to find the ratio of travelers in each travel mode.

3.4 Data Analysis

The results get from the estimation will be analyzed in this section. From data analysis, we can conclude the effect of P&R facilities construction on bus users and the influence in car users by introduction of P&R facilities.

3.4.1 Analysis on non-vehicle residents travel mode

Since in this pattern, all the residents don't hold vehicles, the calculations in 10kilometer and 20kilometer have the same answer. There are 357 residents in the target area without a vehicle, and the travel modes for them to choose are limited in walking to railway station then taking a train to city center or taking a bus to the railway station then transferring to a train. From the calculation, we know the number of the residents who have a possibility to choose the travel mode of walking to the railway station is 53. Comparing the total cost of two travel modes, all the residents living in the cover area of the railway station choose the travel mode of walking to the railway station since the cost is cheaper than that of the mode of taking a bus. Fig. 3-14 shows the ratio of two travel modes.

Since there is no effect on the ratio of each travel mode during the introduction of P&R facilities, it is unnecessary for us to discuss the change of travel behavior after the P&R facilities being introduced. In the following sections, we focus on the residents who have vehicles and find the change of the travel behavior before and after P&R facilities being introduced.

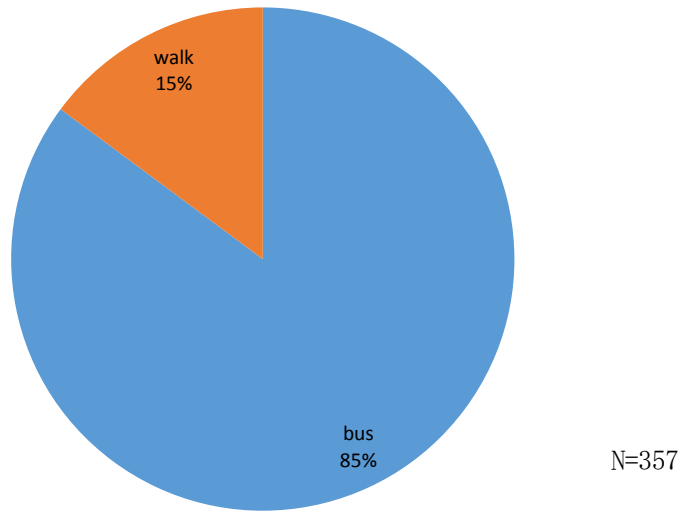


Fig.3- 14 Ratio of non-vehicle residents travel behavior

3.4.2 Analysis on vehicle holders travel mode

Residents who have a possibility to drive a car can choose the travel mode from all the four travel modes we mentioned in section 3.2. The analysis has been separated into two parts, the ratio of each travel behavior before the P&R facilities being introduced and the ratio of each travel behavior after the P&R facilities being introduced.

3.4.2.1 Residential area 10km away from city center

We analyze the residential area from the city center 10 kilometers away at first.

Before the introduction of P&R facilities, there are three travel modes provided: walking to the railway station then taking a train to city center; taking a bus to the railway station then transferring a train and driving to the city center. By comparing the total cost of each travel mode, we can obtain the ratio of each travel mode as Fig. 3-15 shows. From the figure, we can conclude that in the existing price, most people have a tendency to drive a car to the city center; 14.57% of residents take bus as their first choice.

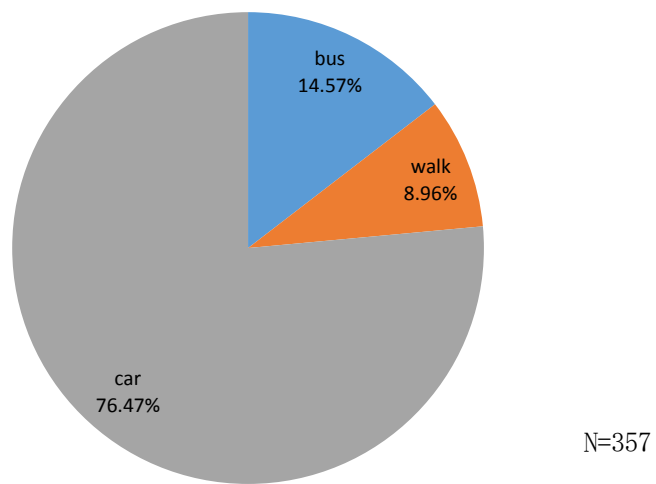


Fig.3- 15 Ratio of each travel mode before P&R introduced

After the introduction of P&R facilities, the ratio of each travel mode changes a lot, from Fig. 3-16 we can find that the P&R facilities occupied most trips from other travel modes. Since the existing price of the P&R fee is 266 yen per day, the total cost of travelling by P&R is the cheapest among all the travel modes. The introduction of P&R has a significant effect on reducing car use, and bus users are reduced at the same time.

Since the effect of P&R introduction to bus users in existing price of parking fee, it is necessary to take action to make sure the number of bus users remains in a normal level. Because of the value of other related parameters are abiding, the only method for us to change the residents' travel behavior is to increase the parking fee. The target is to find a price which the number of bus users is exactly in the same level before the introduction of P&R facilities. When the price of the parking fee is increased to 1,526 Yen per day, the goal can be achieved. The result is shown by Fig. 3-17.

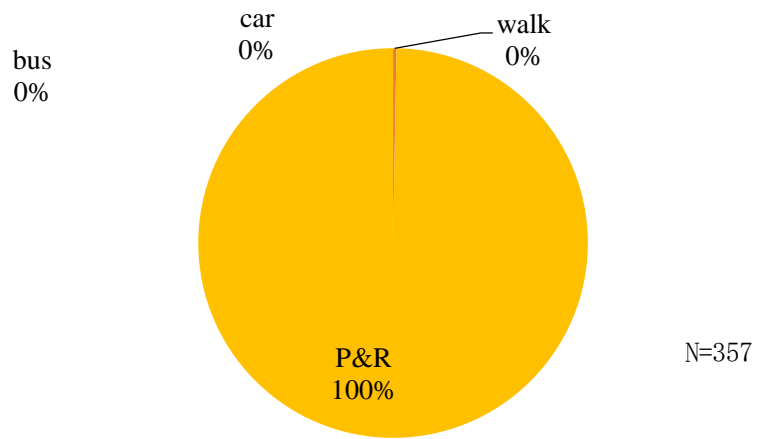


Fig.3- 16 Ratio of each travel mode after the introduction of P&R facilities

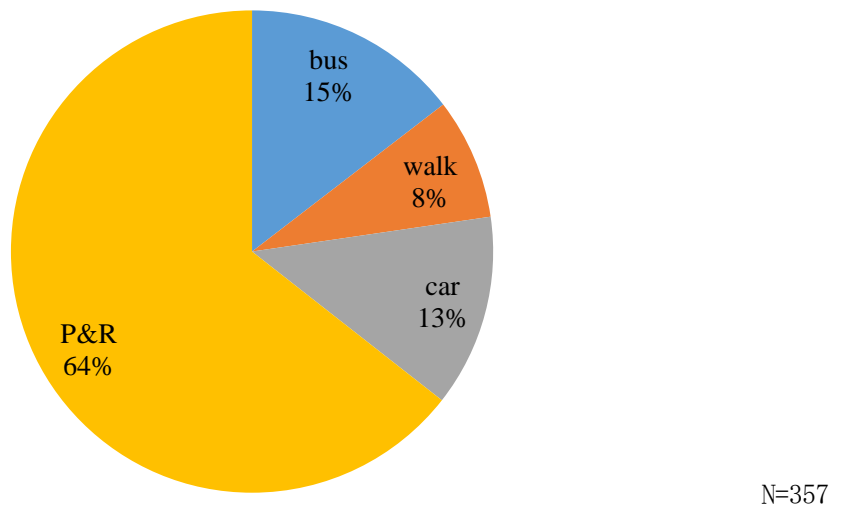


Fig.3- 17 Ratio of each travel mode when P&R parking fee is 1,526 Yen/Day

3.4.2.2 Residential area 20km away from city center

The calculation of 20km pattern is similar to that of 10km.

Before the introduction of P&R facilities, the ratio of each travel mode is the same as that of 10km away from the city center. However, due to the distance between residential area and city center, it is more adverse for people who drive to city center, so the number of bus users increased into 55. Fig. 3-18 shows the details.

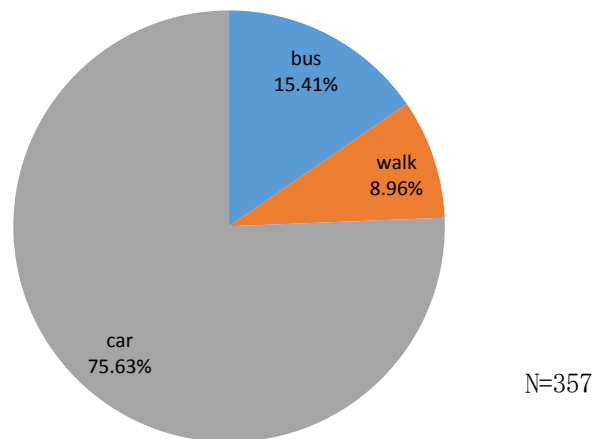


Fig.3- 18 Ratio of each travel mode before P&R introduced

After introducing the P&R facilities, all the residents change their travel behavior into P&R. For the existing price of parking fee in this area is 215Yen per day, the total price is the cheapest among all the travel modes. Fig. 3-19 explains the details.

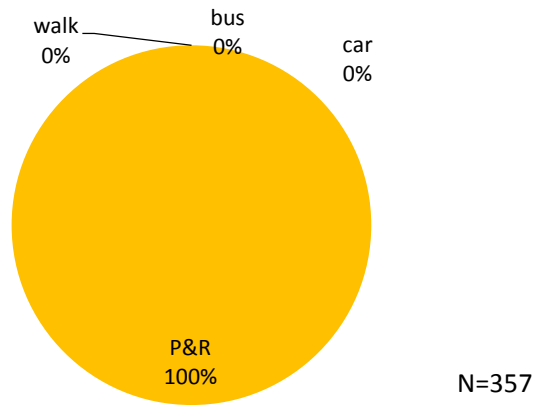


Fig.3- 19 Ratio of each travel mode after the introduction of P&R

It has been found that increasing the price of P&R parking fee is the way to find balancing situation, when the price of P&R parking fee reaches 1,535 Yen per day, the number of bus user can remain in the normal level. Fig. 20 shows the details.

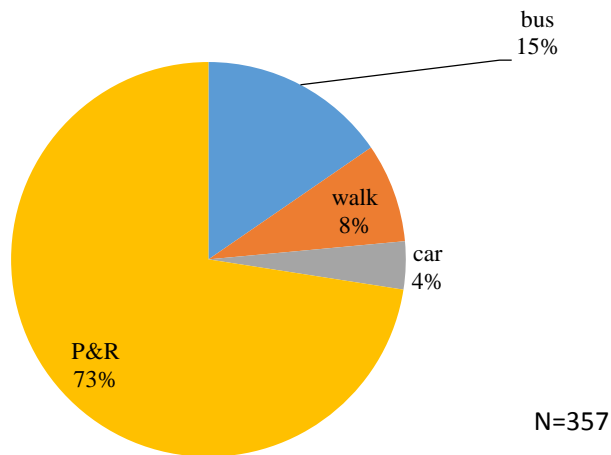


Fig.3- 20 Ratio of each travel mode when the price of P&R parking fee is 1535Yen/Day

3.4.3 Relation between P&R price and total general cost

From searching the balance situation by increasing the price of P&R parking fee, we obtained many patterns and the proportions of each travel mode that are different when P&R parking fee is different. The proportions of each travel mode with different P&R parking fee are shown by Fig. 3-21 and Fig. 3-22 which represents the residential area 10km away from city center and the residential area 20km away from city center. We also noticed that the general cost of the total residents lives in the target area. The relationship between the price of P&R parking fee and total general cost in 10km area and 20km area are shown by Fig. 3-23 and Fig. 3-24. The total general cost includes gasoline cost, time cost and railway ticket. The figure shows that the total general cost is not in the lowest level when the price of P&R is 1,526Yen/day in 10km area and 1,535Yen/day in 20km area. The lowest point of the two curves in the figure appear when the price of P&R parking fee is at the lowest level—the existing price of P&R parking fee.

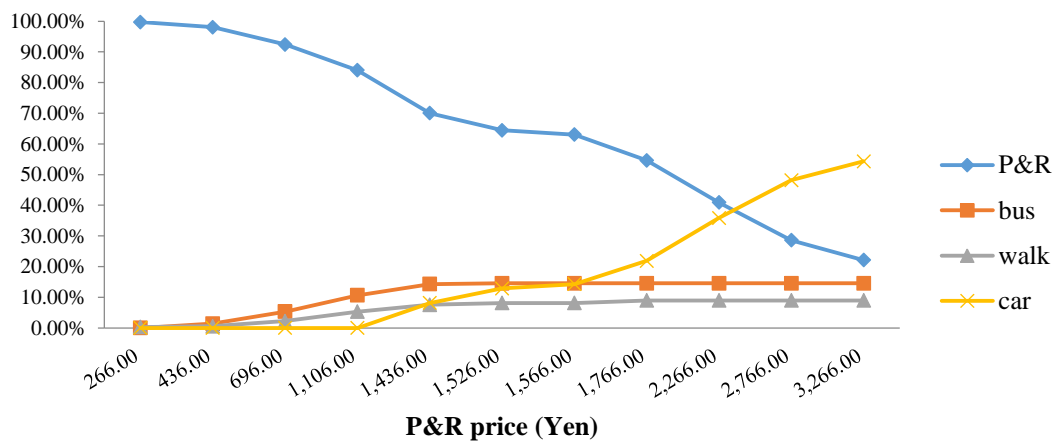


Fig.3- 21 Proportion of each travel mode in different prices of P&R parking fee in the area 10km away from city center

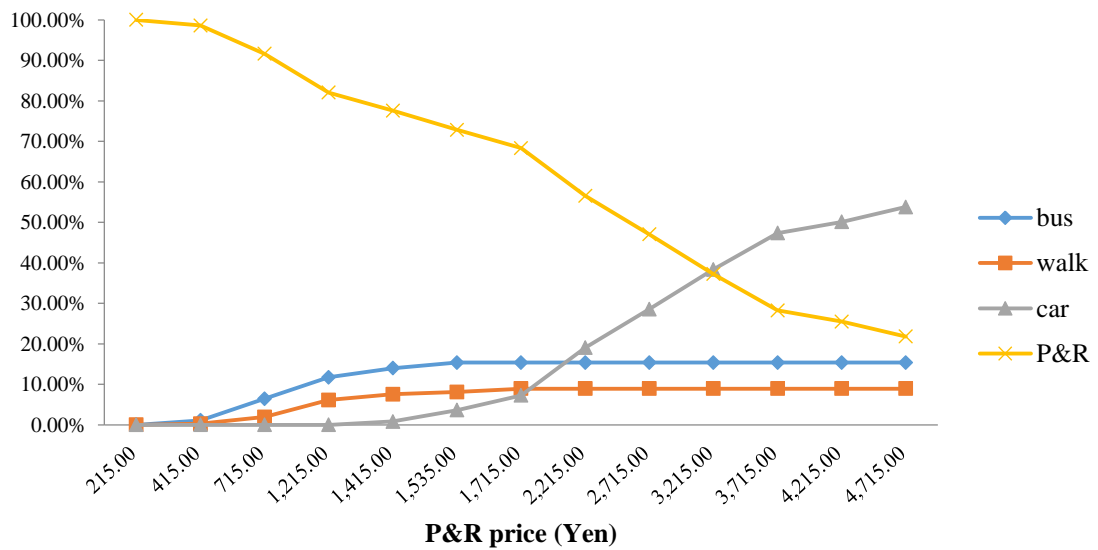


Fig.3- 22 Proportion of each travel mode in different prices of P&R parking fee in the area 20km away from city center

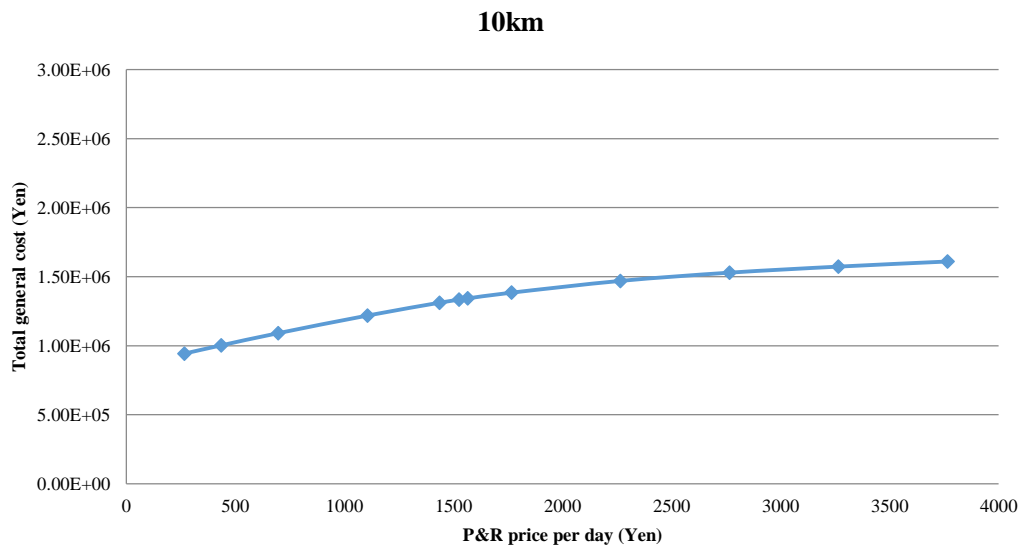


Fig.3- 23 P&R price and total general cost in the area 10km away from city center

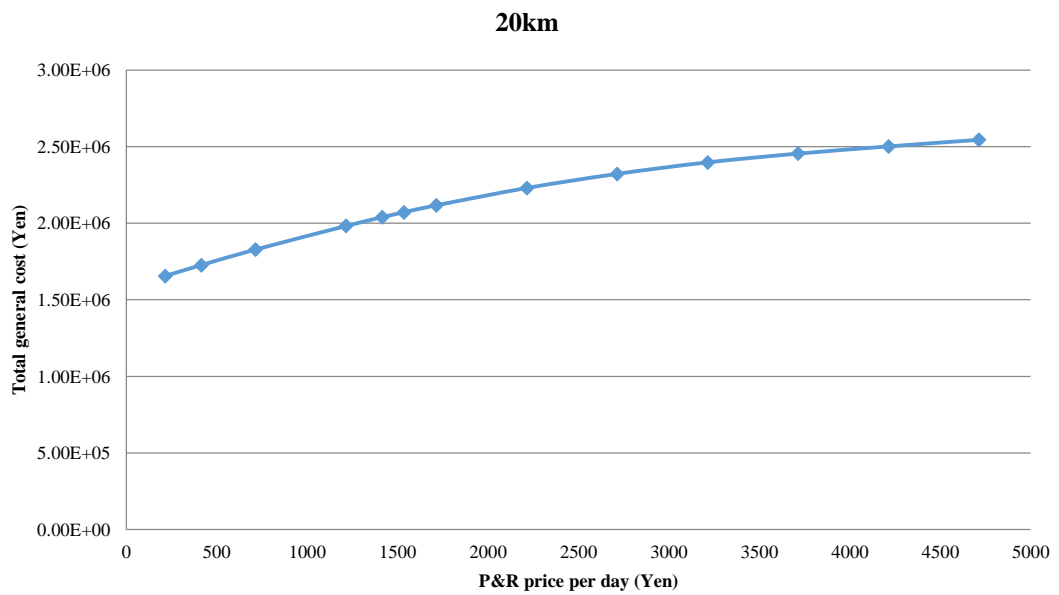


Fig.3- 24 P&R price and total general cost in 20 km away from city center

3.5 Discussion and Summaries

From the data analysis in previous section, we find it is difficult for the policymakers to set a proper plan to maintain the bus operation and ensure the total general cost in the lowest level. In the section of discussion, several solutions will be proposed to achieve the goals.

3.5.1 The effect of P&R facilities construction on bus users

Form the estimation and data analysis we can conclude that the introduction of P&R facilities will assault the operation of bus. Since the existing price of P&R parking fee is at a very low level, when P&R is introduced, people will choose the cheapest travel mode by the method of price-oriented. Though car users are also significantly reduced, however, when the introduction of P&R facilities affect the operation of bus, it is possible for the bus company to abolish the route which is not profitable. At the position of the residents who cannot drive a car, the only way of travel they can choose is walking. For the residents who live far away from the railway station, it is very inconvenient to walk to the railway station.

To avoid the situation, we increased the price of P&R parking fee to find a balancing situation where the bus user can remain in the previous level as the time the P&R facility is not introduced. Finally, we found that when the price of P&R is 1,526Yen/day in 10km area and 1,535Yen/day in 20km area bus users are exactly in the normal level.

3.5.2 Measures of maintain bus operation

Since the relationship between the price of P&R parking fee and total general cost given in the last section shows that in the balancing situation the total general cost is not in the lowest level, the measures of this issue have two starting points: maintaining the bus users and keeping the total general cost in the lowest level.

To maintain the bus operation, the measure of the P&R pricing issue is to increase the price of P&R parking fee until the bus users reach to the normal level.

To keep the total general cost in the lowest level, the measure of the P&R pricing issue is to keep the price of P&R parking fee at the existing level. Since the measure of keeping the P&R parking fee will lead the bus operation to a negative situation, other measures are needed to keep the bus operation. An effective measure is that the local government subsidy helps the bus company to keep the route running. Since the total general cost of all residents who live in the target area is cheaper than that of the bus users in the normal level, the social general cost will be decreased by setting the price of P&R parking fee in the existing price level. Another plan is to consider the cooperation between the railway company and the bus company. Since the introduction of P&R can increase the number of railway users, as a company with increased income, it can cooperate with bus company to

ensure the number of bus users by introducing a coupon policy.

3.5.3 Further research plan

The object we studied is a simple hypothesis model in which the target area and samples are all assumed; there are still many issues remained in the P&R pricing problem.

In further research, it is necessary to initiate an investigation in an area in reality. By listening to the residents who live in the area we can get real data and that will make the result different.

At the same time, we noticed that the implementation of traditional P&R is not easy to obtain the support of related stakeholders. Some cities have a tendency to transfer to the new type of P&R.

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Chapter 4

Park and ride in large-scale shopping center in Fukuoka, Japan

4.1 Introduction

As a method of transportation demand management (TDM), P&R is introduced by various cities and areas. P&R facilities allow commuters park cars and transfer to a bus, railway or carpool for the remainder of the trip. In western countries, P&R lot construction and maintenance are usually targeted by the government. On the other hand, in Japan, there are few P&R lots provided by the local government. Private parking lots are usually used as a P&R car park and commuters have to pay a monthly parking fee for a parking space. However, it is hard to guarantee the scale of the private parking lots near the public transport, some car parks only provide several parking spaces for the P&R commuters. On the other hand, as we mentioned in last chapter, the introduction of P&R may occupy the bus users and it is hard for all related stakeholders to cooperate to solve this situation. In addition, an uncompetitive monthly parking fee makes some commuters drive to city center

directly instead of P&R.

In case of this situation, a new type of P&R has risen. Local government focuses on the large-scale shopping center nearby the public transport. The large-scale shopping centers in the city branch are prescribed to build spacious parking space to avoid traffic congestion by law. Large car park ensures there are enough parking spaces for customers shopping on weekends, however, on weekdays, customers decrease rapidly, leading to lots of spare parking spaces. The government cooperates with the large-scale shopping centers using spare parking spaces as P&R car park on weekdays. Commuters can use the parking space by buying gift certificates instead of paying a parking fee. This kind of P&R system started in Kanazawa city in 1996 and is extended to other cities in Japan. In Fukuoka city, the local government introduced P&R in large-scale shopping centers in the year of 2012.

There is a similar P&R system in the US which is called ‘shared use P&R’. Shared use P&R is defined as park and ride spaces that can be used to serve two or more individual land uses without conflict or encroachment. Cooperation partner can be large-scale shopping centers or other public facilities like church. In the US, shared use P&R is usually arranged by the transit agencies or even commuters themselves yet in Japan P&R in large-scale shopping centers is a government-led scheme.

This chapter investigates the implementation of P&R in large-scale shopping centers in Fukuoka city, Japan through the review of existing literature and feedback from local government. After providing some methodological details, it takes steps to outline the findings from literature reviews and interviews with the local government. It offers views on the factors that make the scheme successful and finally. It looks forward to the future and considers developments on the P&R in large-scale shopping center scheme.

4.2 The implementation of Fukuoka P&R in large-scale shopping center

In Fukuoka city center, there are two main commuter destinations ----Tenjin and Hakata. Depending on Northern Kyushu person trip surveys taken in 1993 and 2005, total daily trips to Tenjin are 26,354 in 1993 and 24,615 in 2005 and trips heading to Hakata are 27,947 in 1993 and 25,310 in 2005. We can find by searching that the absolute daily trips to two destinations have decreased in 12 years. On the other hand, ratio of trips from suburban areas has increased, 21.9% in 1993 and 33.1% in 2005 heading to Tenjin and 28.1% in 1993 and 35.3% in 2005 heading to Hakata (Fig.4-1 & Fig.4-2). Thus, the local government focused on the suburban areas as the target and investigated large-scale shopping centers in the city branch to pick up target shopping malls.

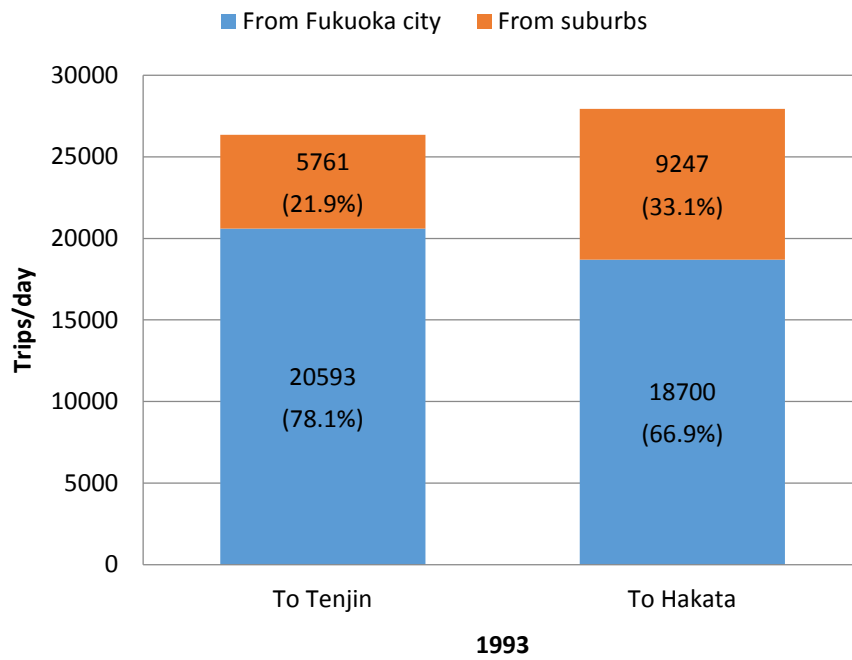


Fig.4- 1 Daily trip to the city center in 1993

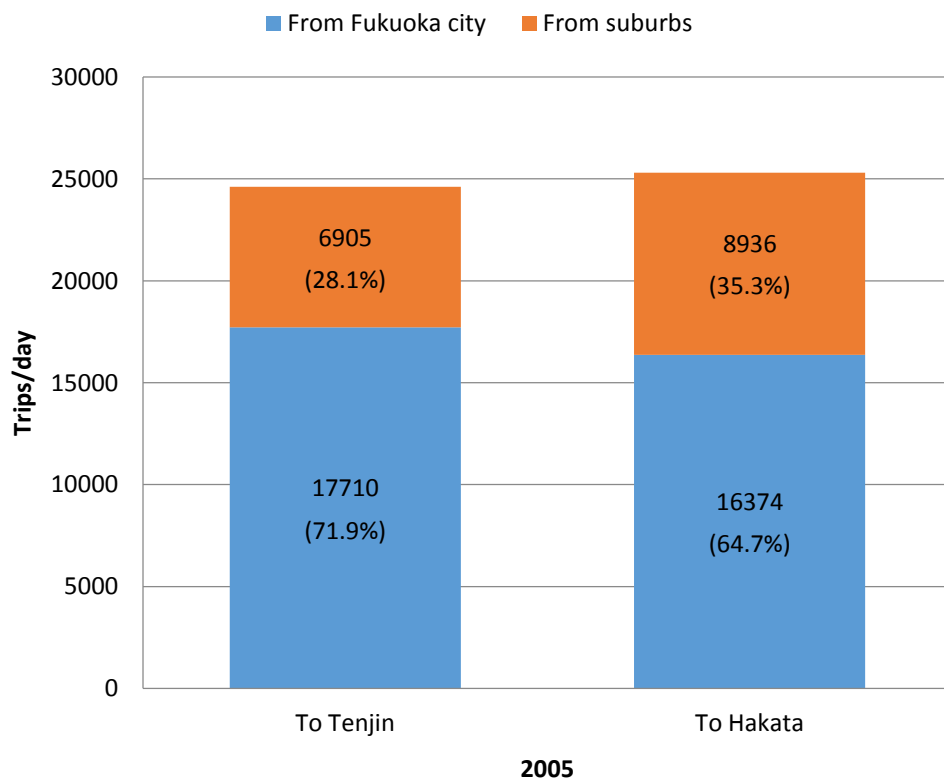


Fig.4- 2 Daily trip to the city center in 2005

Fukuoka city government launched the scheme of P&R in large-scale shopping centers from the year of 2012. In 2011, the company signed a comprehensive cooperation agreement with the local government on the details of P&R cooperation, and on this basis the government began negotiations with qualified shopping centers. In November 2012, the original scheme of P&R in large-scale shopping centers has achieved the cooperation in the form of social practice.

There are 8 shopping centers carrying out the P&R cooperation schemes (Table 4-1), 6 stores are under full-scale implementation (Konoha Mall Hashimoto, Aeon Mall Kashibahama, Aeon Mall Fukuoka Ito, Aeon Mall Chikushino, Aeon Karatsu Shopping Center, Aeon Mall Fukutsu). Aeon Mall Fukushige and Aeon Shima Shopping Center are at the stage of social experiments.

Commuters using car park need to follow these three requirements: application, commuter pass, buying gift certificates or charging electronic money.

Table 4- 1 Implementation of P&R in large-scale shopping centers in Fukuoka city

Name of large-scale shopping center	Number of parking spaces	Monthly cost(Yen)	Remarks
Konoha mall Hashimoto	50	6000	
Aeon mall Kashiihama	70	5000	Buying gift certificates or charging electronic money
Aeon mall Fukuoka Ito	50	4000	Buying gift certificates
Aeon mall Chikushino	70	5000	Buying gift certificates
Aeon mall Fukutsu	70	5000	Buying gift certification or charging electronic money
Aeon Karatsu Shopping center	30	5000	Buying gift certification or charging electronic money
Aeon mall Fukushige *	30	5000	Buying gift certification or charging electronic money
Aeon shopping center Shima *	20	5000	Buying gift certification or charging electronic money

*under social experiment.

4.3 Methodology

To investigate the main problems of P&R in large-scale shopping center scheme and the implementation procedure, a qualitative methodology was applied using both literature review and local government interviews.

For a literature review, reports and articles are collected and summarized. Fukuoka city P&R countermeasures outsourcing report provided by Fukuoka municipal government was mainly used to investigate the implementation procedure in this section.

The study also solicited feedback from the council leader of the P&R scheme to complement the literature reviews and to find the problems during the negotiations with both questionnaire and face-to-face methods used.

4.3.1 Literature review

The study's literature reviews mainly used Fukuoka city P&R countermeasures outsourcing report 2011 which reported the preparatory work before the scheme was launched. From the report, we summarized the selection criteria of the shopping center and the implementation procedure.

As we indicated in the preceding section, the target shopping mall should be selected from the suburban areas near Fukuoka city. Total floor space over 10,000m² is defined as a large-scale shopping center and there are 60 shopping centers complying with the requirements. Other selection criteria are also required: parking space over 1,000 and the distance to the nearest bus stop or railway station less than 500 meters. Follow these conditions, local government screened out 11 shopping malls from the 60 alternative objects. Table 4-2 displays the names of the shops and the sphere of the shops.

Table 4- 2 Selected shops and the sphere of the shops

Name of shopping center	Shop sphere
Aeon mall Kashiihama	Higashi District
Konoha mall Hashimoto	Nishi District, Sawara District
Aeon mall Fukuoka Ito	Nishi District, Itoshima City
Aeon mall Chikushino	Chikushino City
Aeon Oonojo SC	Kasuga City, Onojo City, Dazaifu City
Youme town Munakata	Munakata City
Sunlive Koga	Koga City, Fukutsu City
Aeon mall Fukutsu	Fukutsu City, Munakata City
IKEA Fukuoka Shinguu	Shinguu Town, Koga City
Torius	Hisayama Town
Aeon mall Fukuoka	Kasuya Town, Shime

From the selected shops, more work has been done to implement the P&R scheme. To compare the objects intuitively, the government developed a grading system (Table 4-3). In this system, several factors like time difference, number of trips, private car share, external environment and shops in Fukuoka city from the Northern Kyushu person trip surveys are scored and the total score will be an essential reference for the decision makers.

Table 4- 3 Selection criteria of the priority implementation area

Score	Time difference (my car - P&R)	Number of trips	Private car share	The external environment	Shopping centers in Fukuoka city
2	>11 min	>1000trips	>20%	-	-
1	1~11min	>100trips	>10%	Applicable	Applicable
0	<0min	<100trips	<10%	Not applicable	Not applicable

The grading results are divided by heading to Tenjin (Table 4-4) and to Hakata (Table 4-5) in two parts. In Tenjin part, taking public transport from Torius and Aeon Mall Fukuoka sphere takes more time than driving to Tenjin directly, therefore, these two shops were not addressed in this grading system. The reason is the same for Konoha Mall Hashimoto, Aeon Mall Fukutsu, Torius and Aeon Mall Fukuoka in Hakata part.

Table 4- 4 Grading results (Heading to Tenjin)

Name of shopping center	Time difference (my car - P&R)	Number of trips	Private car share	The external environment	Shopping centers in Fukuoka city	Total score
Aeon mall Kashiihama	1	2 (2709trips/day)	2 (25.4%)	1	1	7
Konoha mall Hashimoto	1	2 (4309trips/day)	1 (19.2%)	0	1	5
Aeon mall Fukuoka Ito	2	2 (1966trips/day)	1 (16.1%)	1	1	7
Aeon mall Chikushino	2	1 (332trips/day)	0 (7.7%)	1	0	4
Aeon Oonojo SC	2	2 (1550trips/day)	1 (13.4%)	1	0	6
Youme town Munakata	1	1 (339trips/day)	1 (17.6%)	0	0	3
Sunlive Koga	1	1 (661trips/day)	2 (25.4%)	0	0	4
Aeon mall Fukutsu	1	1 (663trips/day)	2 (21.4%)	1	0	5
IKEA Fukuoka Shinguu	0	1 (410trips/day)	2 (20.3%)	0	0	3
Torius	- (Not covered)	0 (69trips/day)	2 (42.1%)	0	0	- (Not covered)
Aeon mall Fukuoka	- (Not covered)	2 (1563trips/day)	2 (39.7%)	1	0	- (Not covered)

Table 4- 5 Grading results (Heading to Hakata)

Name of shopping center	Time difference (my car - P&R)	Number of trips	Private car share	The external environment	Shopping centers in Fukuoka city	Total score
Aeon mall Kashiihama	0	2 (2567trips/day)	2 (26.5%)	1	1	6
Konoha mall Hashimoto	- (Not covered)	2 (2670trips/day)	1 (18.7%)	0	1	- (Not covered)
Aeon mall Fukuoka Ito	2	2 (1192trips/day)	1 (14.2%)	1	1	7
Aeon mall Chikushino	2	1 (857trips/day)	2 (28.7%)	1	0	6
Aeon Oonojo SC	0	2 (2344trips/day)	2 (24.6%)	1	0	5
Youme town Munakata	2	1 (179trips/day)	0 (7.6%)	0	0	3
Sunlive Koga	2	1 (514trips/day)	1 (13.7%)	0	0	4
Aeon mall Fukutsu	- (Not covered)	1 (393trips/day)	0 (9.2%)	1	0	- (Not covered)
IKEA Fukuoka Shinguu	2	1 (350trips/day)	1 (14.0%)	0	0	4
Torius	- (Not covered)	0 (78trips/day)	2 (51.7%)	0	0	- (Not covered)
Aeon mall Fukuoka	- (Not covered)	2 (1588trips/day)	2 (35.7%)	1	0	- (Not covered)

According to the grading results, Aeon Mall Kashiihama, Aeon Mall Fukuoka Ito, Aeon Onojo get higher score in Tenjin part and Aeon mall Kashiihama, Aeon Mall Fukuoka Ito, Aeon Mall Chikushino get more competitive score in Hakata part. Therefore, the local government decided to choose these four shops at the initial P&R in large-scale shopping center implementation objects. Since these shops all belong to the same retail chain enterprise, negotiations conducted were regarded as relatively simple.

4.3.2 Local government feedbacks

In this section, we investigated the procedure of the initial P&R implementation, problems between shopping center managers and the local government and their solutions. To achieve these aims, interviews were undertaken with a municipal government officer, who has participated in all negotiations between shopping centers and the government. Both face-to-face conversation and e-mail were employed during the interview, interviewee provided specific contents of negotiations so that the process of negotiation was able to be clearly presented.

According to the information from the interviewee, negotiations with shopping center started in June, 2012, before the initial P&R pilot program was launched in November 2012, ten negotiations have been conducted including one meeting with

the Fukuoka prefecture government and the final council meeting. The main contents and problems of each negotiation are provided as follows:

The first negotiation took place in 29th June, 2012. The local government explained the scheme of P&R in large-scale shopping center to the company headquarters, the implementation schedule expected in October was also mentioned. The response from the company headquarters was positive that they were prepared to take part in this scheme according to the comprehensive partnership agreement. It has been suggested whether it is possible to implement in some specific days, however, it is difficult to get the government's answer because of the characteristics of P&R.

In 18th July, the second negotiation was conducted. Same participants discussed the target shopping centers. The local government selected four shops (according to the interviewee's requirement, using A, B, C, D to represent the shop names), reasons for selection were also explained. Consider that Shop D doesn't have the ownership of the parking lot, it was difficult to implement the plan, and the commercial facility recommended choosing Shop A and Shop B.

Third time on 24th July was a meeting with Fukuoka prefecture government to exchange P&R information in the case of the duplicate selection.

On 31st July, the negotiation restarted between the local government and the company headquarters. After explaining the information of each shop, the company doubted whether there are enough users in Shop A since in its sphere people commute by express bus, the time difference effect was also suspected. Regarding these problems, the local government proposed a one-year pilot program. According to the hearing from the company, Shop C was under the situation of lacking parking space and Shop D didn't have the ownership of the car park. On the other hand, Shop B has already taken part in P&R, therefore the local government decided to focus on Shop A.

On 9th August, the initial negotiation with Shop A was conducted. After the explanation from local government, the attitude of the manager was negative. Several problems were put forward:

- Lack of conditions for implementation like gate bar or parking lots maintenance agency
- Lack of staff to deal with the complicated procedures
- Conflict between P&R users and other customers
- Increase of illegal parking

It was difficult to answer all the questions, so the government arranged next meeting and collected the answers during the preparation.

In the second negotiation with Shop A on 21st August, the local government brought the answers to untie the doubts:

- Information of existing shop in another city has implemented without a gate bar
- Avoiding the heavy workload by controlling the number of initial applicants, the duration of contract update could be 1 month or 3 months
- Setting a specific P&R area is suggested, for the P&R users, the parking permit is also required
- From the hearing with existing shops in other cities, illegal parking was not found

The shop manager accepted the explanation but doubted if the mode of buying gift certificates instead of paying parking fee was legitimate.

On 7th September, after introducing the existing four shops in other cities, the local government dispelled the last question raised by Shop A. At this time, the local government has answered most of the doubts, and the attitude of Shop A has also changed. Shop A accepted the pilot program and suggested the implementation period from 1st November 2012 to 30th April, 2013.

Two more meetings between Shop A and local government were held on 20th September and 5th October, to confirm the details of the implementation.

On 12th October, the first council meeting was held prior to the implementation. The participants included Shop A, Fukuoka municipal government, Fukuoka prefecture government and bus company. The main issue was tantamount to confirming the schedule of the scheme and assigning the campaign tasks.

On 19th October, the press release was issued. On 1st November next month, the initial scheme of P&R in large-scale shopping center has been launched. Table 4-6 shows the details of each negotiation.

Table 4- 6 Negotiation overview of Fukuoka city and commercial facilities

	Fukuoka City	Commercial Facilities
Summary : Conducted consultations on implementing P & R based on packaging collaboration agreements. We set the target of the P & R implementation schedule. Store side response: I want to consider it positively.		
2 nd time Date : 2014.7.18 Place : Commercial facility Fukuoka City: Director and Clerk of Public Transport Promotion Division Commercial Facility: South-Fukuoka business division personnel	Explanation of the selection and selection reasons for the shop (shop A Shop B Shop C Shop D) that implements P & R. →Priority will be given to shop A and shop B.	→It is difficult to proceed with measures because D stores have commercial stores in their parent company. Why do not you consider it from shops A and B, which are directly managed stores?
Summary: We choose shop A and shop B as candidates.		
3 rd time Date : 2012.7.24 Place : Fukuoka City Public Transport Promotion Division Fukuoka City: Director and Clerk of Public Transport Promotion Division Prefecture: Director and Clerk of Planning and Transportation Division	Explain P & R consultation status with commercial store. →We are considering A, B, C, D 4 stores. We want to avoid taking time to implement the measures, so we will make adjustments individually and consider them all together before the implementation.	→The prefecture also entered into a collaboration agreement in April and is in contact with each store around May. →Regarding shop choice, it does not cooperate with the prefecture. We formed a council from what is positive for P & R. →I would like to proceed while providing information so that both prefecture and city will not be inefficient, such as consultation to the same store.
Summary: Similar to the city Consultation with prefectures that are considering P & R measures as commercial stores. Information provision, information exchange.		
4 th time Date : 2012.7.31 Place : Commercial facility Fukuoka City: Director and Clerk of Public Transport Promotion Division Commercial Facility: South-Fukuoka business division personnel	Please tell me about the situation of the 4 selected stores. →It is possible to explain the effect of shortening time and to see the state of social experiment for about one year about the number of users. I would like to do so because store A can perform P & R newly.	→A store: concern about whether time shortening effect and users will grow because P & R using city high-speed bus is done. →Although there is room for parking lot B, it is in a situation where store C already undergoes P & R, C is receiving a request to increase the number from contractor, but store D is difficult to implement measures.
Summary: We grasped the situation of the four selected stores and explained the problems worried about the store side.		
5 th time Date : 2012.8.9 Place : Store A Fukuoka City: Director and Clerk of Public Transport Promotion Division Store A Head of Human Resources General Affairs Section	→Contracts with customers and parking lot management etc are considered by the store side. The merit of the shop side is kept if the method of implementation is a gift certificate purchase method rather than a regular fee. →In addition to presenting an entry permit, P & R contractors think that it is possible to suppress illegal parking to a certain extent by limiting parking spaces. →When considering on the premise that the customer performs illegal parking, there may be no countermeasure.	In order to implement P & R, there is no agreement on the condition (such as the fact that the gate bar is installed, maintenance of the parking lot etc), nothing complicates the administrative procedure, concerning all new contracts monthly update etc. I am concerned about whether it can be done with a service counter. There is concern about an increase in illegal parking. →Since the gate bar is not installed, there is concern that troubles may occur between the customer who is using it properly and the customer who is illegally parked. →As a conclusion, I think it is difficult to implement P & R at store A.
Summary: We cannot resolve all the situation explanations and concerns to the executing stores. Tell the city's intention to the manager, promise to respond with the manager at a later date, store side response: negative.		
6 th time Date : 2012.8.21 Place : Store A Fukuoka City: Director and Clerk of Public Transport Promotion Division Store A: Manager, Head of Human Resources General Affairs Section	→It is implemented at stores outside the city. →We will report it at the next consultation. →In order to prevent the occurrence of many new procedures, the number of	Is there a P & R case at stores that do not have a gate bar? Please tell me about the correspondence of the shop when dealing with complaints from customers. I am concerned about the burden of administrative procedures on the store side.

	<p>units is initially set to be a small number and incremented step by step. →It can be grasped with a permit.</p> <p>→Complexity can be reduced if the update time is set to 1 month or 3 months. →Confirm with stakeholders and respond at the next consultation.</p>	<p>→What to do if your update is delayed.</p> <p>→In that case, you must always attach security guards and monitor them.</p> <p>→I want to grasp the number of users whether there is no legal problem.</p>
<p>Summary: Discussed about the image of P & R implementation at store A, and explanation on the problem the store had.</p>		
<p>7th time Date : 2012.9.7 Place : Store A Fukuoka City: Director and Clerk of Public Transport Promotion Division Store A: Manager, Head of Human Resources General Affairs Section</p>	<p>As a result of interviewing 4 stores under P & R, it was said that complaints such as illegal parking have not occurred. Regarding the contract, we adopted the gift certificate purchase system at any store, and had made it simple response by application form. We also told that bus operators wanted to cooperate, which introduced the number of users and the number of flights for bus demand.</p>	<p>→Anxiety resolution, feelings have changed.</p> <p>→I would like to set the social experiment period as half a year from November 1st to April 30th 2013.</p>
<p>Summary: Agreed on P & R implementation at store A. Determination of implementation method and period.</p>		
<p>8th time Date : 2012.9.20 Place : Store A Fukuoka City: Director and Clerk of Public Transport Promotion Division Store A: Manager, Head of Human Resources General Affairs Section</p>	<p>→We would like to continue our efforts even when the contract number is small. I would like to conduct a questionnaire to the contractor, improve the conditions and carry out full-scale implementation. I explained the establishment of the council.</p>	<p>What the number of users achieved can we shift to full-scale implementation?</p>
<p>Summary: I discussed what P & R implementation schedule at store A was discussed and set up a council.</p>		
<p>9th time Date : 2012.10.5 Place : Store A Fukuoka City: Director and Clerk of Public Transport Promotion Division Store A: Manager, Head of Human Resources General Affairs Section</p>	<p>Press release, press release, leaflet installation etc. explained.</p>	
<p>Summary: This is the confirmation about the P & R implementation schedule at store A.</p>		

In March 2013, in order to clarify the conditions for the transition to full-scale implementation, a questionnaire survey was conducted on P&R users before the end of social experiments. Following this questionnaire result, the second meeting took place on March 26, 2013, and the questionnaire result was analyzed and evaluated. We obtained valid responses from 22 of 50 users. Results of the questionnaire are presented in Fig. 4-3 - 4-5. From Fig. 4-3, 23% of users had automobiles before commuting to P&R. And 45% of users can read from bus and bicycle commuting to P&R. In addition, as shown in Fig. 4-4, 81% of users increased their shopping amount, and revenues from commercial facilities increased after introducing P&R. And, referring to Fig. 4-5, when more than 80% of users were continuously performing even after social experiments, many answered that they wanted to use Shared use P&R, so the planner decided that it can shift to full-scale implementation.

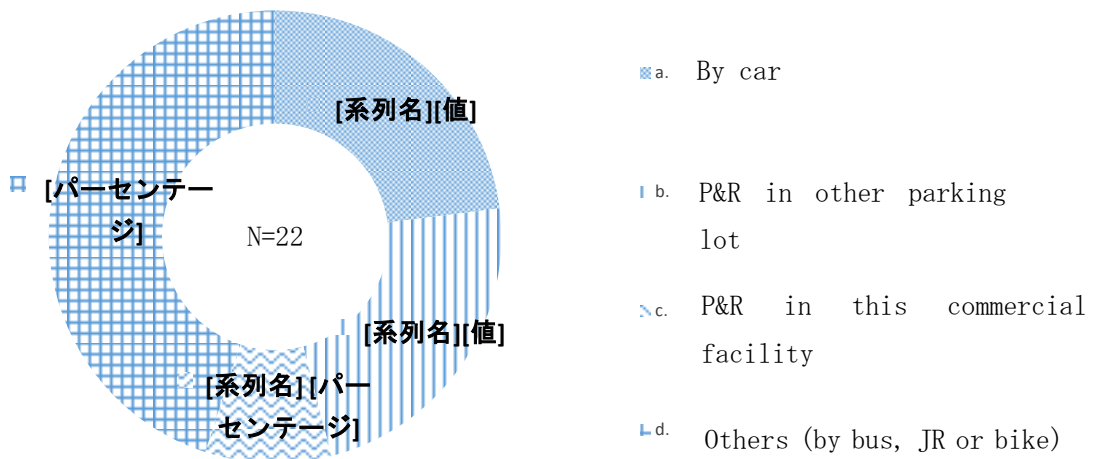


Fig.4- 3 Commuting before P&R use

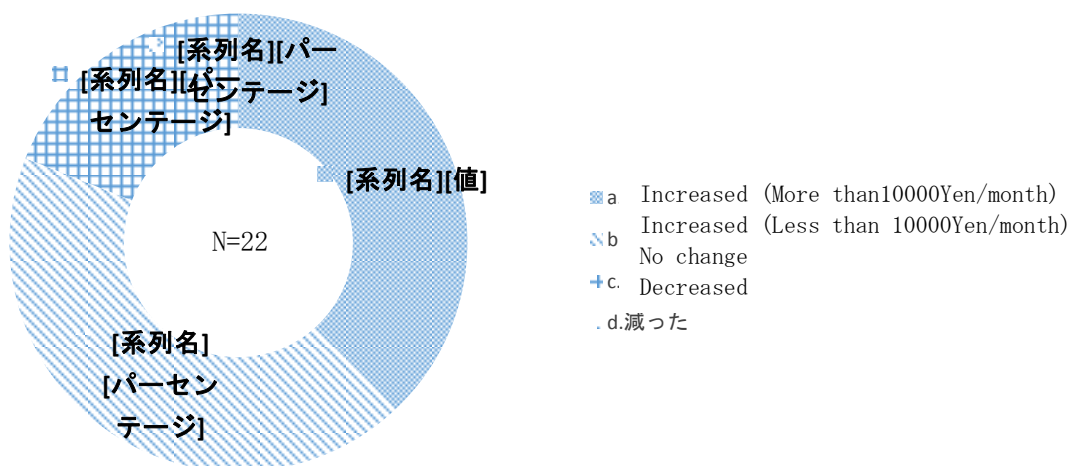


Fig.4- 4 Changes in shopping amount before and after P&R usage

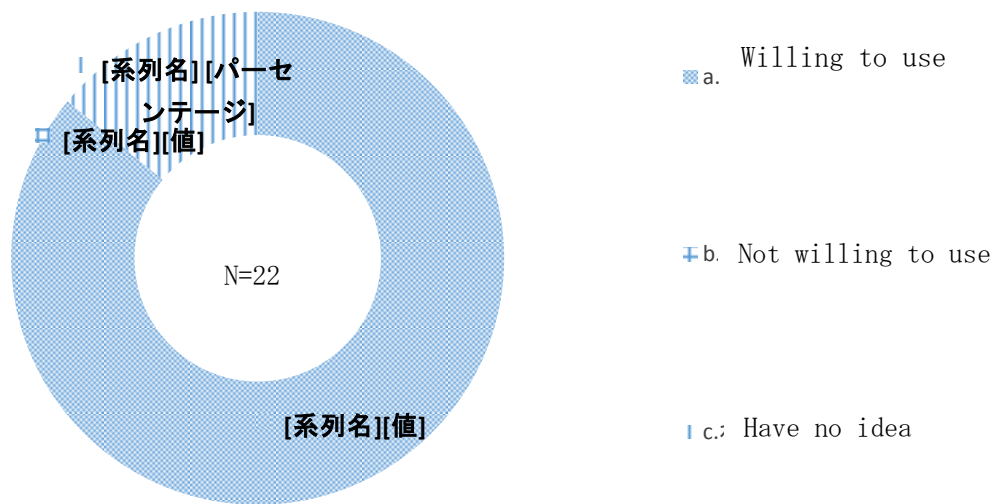


Fig.4- 5 Percentage of people who want to continue using P&R even after social experiment

4.4 Study findings

The core findings of this chapter revolved around the policy progress and operation of P&R in large-scale shopping center scheme. It was obvious that the local government led the policy at the initial time and adequate preparation ensured an agreeable cooperation partner to implement the plan smoothly, thus we can find the attitude of the company headquarters was positive. However, negotiations with the branch shop seemed not so success at first because it was not like the company headquarters considering the social contribution. The priority consideration of the branch shop manager is the benefit of the shop. The main issues of concern to the shop can be divided into three parts: chaotic management of the parking lots, the conflicts between customers and P&R users and the increase of parking management costs. Although the branch shop didn't show interest in whether the P&R scheme would affect people's commuting, they accepted the cooperation plan after the local government answered their concerns. The branch shop believed that the method of purchasing gift vouchers every month will be an opportunity to expand the number of potential customers.

Some unanticipated findings were unfolded during the study. Unlike some shared use P&R schemes in the US in whose implementation the transit agencies played a major role, Fukuoka P&R in large-scale shopping

center was led by the local government from the very beginning. Public transport companies only participated in the campaign part after all policy details have been discussed by the government and the shopping center.

4.5 Conclusions and recommendation

The principal objective of this study was to investigate the implementation of the P&R in large-scale shopping centers in Fukuoka city, its policy origin, procedure and the operation. First, we introduced the background of the P&R policy in Japan. Compared with western countries, the scale of P&R car park in Japan is smaller and has a low user growth. Since it was hard to provide large-scale land for the P&R parking lots construction, the local government switched their focus to the large-scale shopping centers in suburban area which own a large number of parking spaces and a low utilization during the weekdays.

Next, implementation information of P&R in large-scale shopping centers was explained. From the first cooperation started in 2012, so far there are 6 shopping centers implementing the P&R scheme including one social experiment and the total number of parking spaces is over 300.

Finally, we investigated the details of the implementation process through both the literature review and the local government feedback. Before negotiating with the commercial facilities, the local government analyzed a considerable sum of shops to select the proper implementation targets. It was fortuitous that the selected objects all belong to the same

retail chain enterprise, which had a smooth negotiation at the initial time. Although there were many doubts raised by the branch shop during the negotiations that had to be solved and the period lasted for about 5 months, the explanations were accepted and finally the local government met the goals.

Considering the current implementation, the scheme of P&R in large-scale shopping centers is thriving and has a potential to be introduced to other cities. However, during the investigation, we also found some problems like the minimal participation of public transport companies during the policy process and the long duration of the negotiations between the local government and the shopping centers. Several ideas to execute the policy are thus recommended. The local government should introduce more about the benefits like the increase of the potential patrons which the branch shop concerned to shorten the negotiation period. Cooperation between the local government and public transport company is also expected during the implementation. For example, changing bus route to cater to the P&R commuters or providing discount fare for the P&R users.

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Chapter 5

A research of the comprehensive evaluate potential shared use P&R facilities

5.1 Introduction

As we mentioned in last chapter, in Europe and the US, for P&R that can promote the use of public transportation, the construction and operation of a large parking lot are covered by tax and the parking fee is low or free. In Japan, it is rare that the administration secures and constructs land for P&R parking lots. Private parking lot is used as P&R parking lot, therefore the size of P&R parking lot is small and parking fee is necessary, which is why the number of P&R users is small. On the other hand, a large commercial

facility has a large parking lot near a station or a bus stop, the parking lot is almost empty on weekdays. Based on this reality, a new form of P&R that started in Sendai in recent years and in collaboration with large commercial facilities has appeared. In the United States, P&R in collaboration with commercial facilities and churches is called Shared use P&R. In Japan, this form of P&R is carried out in various places, but it is not necessarily carried out under the concept of shared use P&R, and there are no proper words to express this form. In this chapter, this form of P&R will be described as Shared use P&R below.

Unlike overseas private voluntary programs, in Japan, we implemented policies in collaboration with commercial facilities. Fukuoka City introduced Shared use P&R in collaboration with large commercial facilities starting from social experiments in 2012. According to the interview with the person in charge of traffic planning in Fukuoka city and the review of related reports, in order to select target shops, we evaluate the prior execution area by store area. In order to introduce a P&R parking lot at the target store, Fukuoka City consulted with the profitable facilities. From the first consultation held in June 2012 until the policy was implemented in November 2012, the negotiations for Fukuoka City and commercial facilities totaled 10 times in total. While negotiating, Fukuoka City explained to the store the reduction in the number of car trips accompanying the introduction of P&R, but the store was concerned about the number of users and management of the parking lot. Fukuoka City

extracted the executable area of P&R measures before implementing the policy, but did not fully evaluate the number of potential users of P&R facilities before implementing the plan. In order to convince the commercial facilities, the analysis results of interest to the store, such as the number of P&R parking lots or the economic impact, are appropriate.

Before implementing Shared use P&R, the overall evaluation procedure can be assumed as shown in Fig. 5-1, we select the shops where we will implement. Next, we grasp the public transportation situation around the selected commercial facilities and analyze the service level of public transportation. At the same time, the condition of the parking lot of the selected store and the commuting situation of the residents in the vicinity of the store are grasped. A traffic mode choice model is established using commuting situation data and the number of Shared use P&R users is calculated. Finally, we assess the economic impact of policy implementation on commercial facilities.

In this chapter, we will focus on Fukuoka City as a case city, taking Shared use P&R as the objective, in order to negotiate smoothly with commercial facilities, before implementing policies, from the choice of target shops, the level of public transportation services and the status of parking lots, we describe the step-by-step comprehensive evaluation method to estimate the number of P&R users and economic impact on the store. Finally, an estimate of the number of P&R users in the case of a

large-scale commercial facility in suburban areas of Fukuoka City is described.

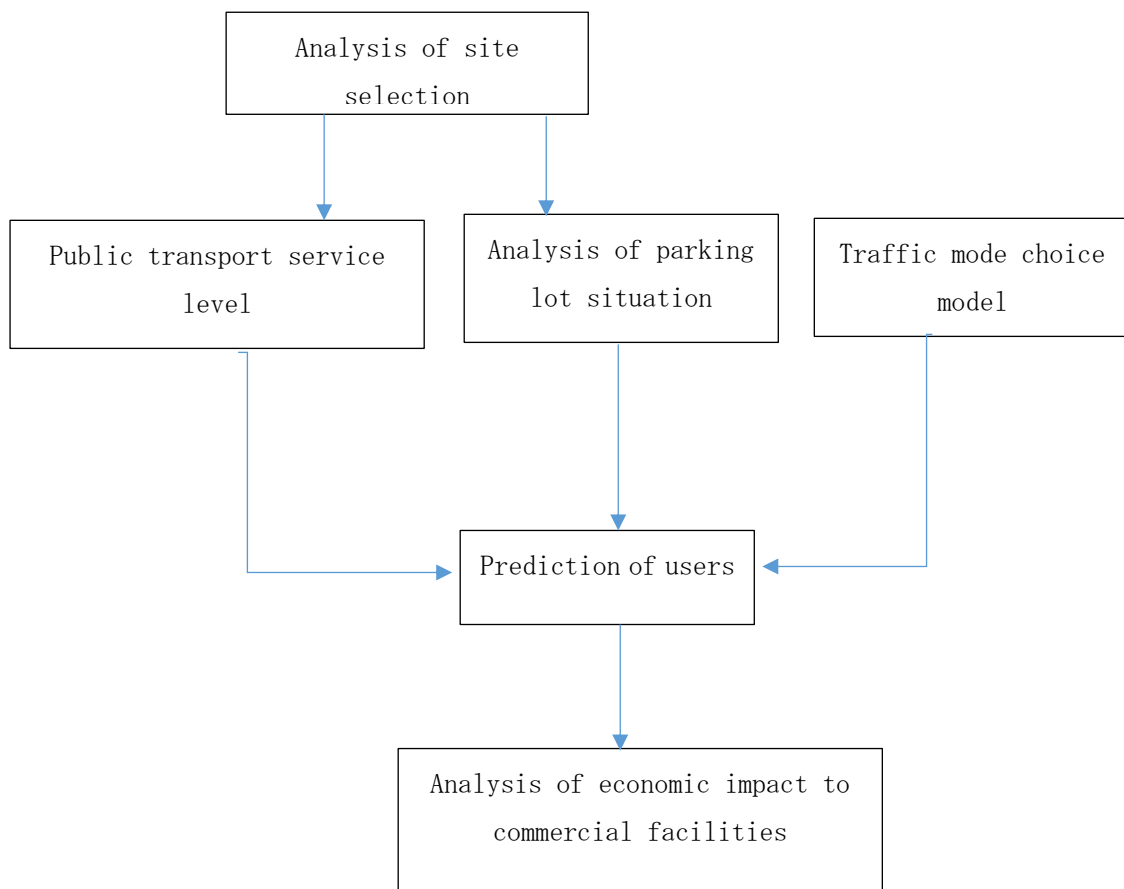


Fig.5- 1 Flowchart of the comprehensive evaluation of shared use P&R

5.2 About Shared use P&R

5.2.1 Introduction of Shared use P&R

In traditional P&R, the administration creates a private parking lot for

P&R in the vicinity of the station and the bus stop in order to alleviate traffic congestion in the downtown area. However, there was a problem that the parking lot's usage rate was low and the dedicated space was wasted. Shared use P&R began in the United States under this background. Shared use P&R is that two or more users purposely use the same P&R space without conflict, and was first proposed by Barton-Aschman Associates in 1983.

There are several examples of Shared use P&R underway led by transportation companies and commuters in the United States. We will introduce the implementation situation.

- Shared use P&R led by King County Subway

A subway company in King County, Washington State, USA, works with Shared Use P&R in collaboration with church and large commercial facilities.

(1) Collaboration with the Church

The King County subway company focused on the high vacancy rate of the church parking lot on weekdays and negotiated with the church around the station on the implementation of Shared use P&R. The way to do it is that the King County subway borrows the church parking lot at a fixed

price and the user uses the church parking lot as a P&R parking lot during commuting time (weekdays). The church side will bear the maintenance cost of the parking lot, and the subway company will provide a sign of P&R.

(2) Collaboration with large commercial facilities

In addition to the church, the King County subway negotiated with large commercial facilities as well. Commuters can use the parking lot of a large commercial facility as a P&R parking lot, and instead of paying parking fee, they are required to shop a certain amount each month. Collaboration was successful, but negotiations with commercial facilities were not smoothly advanced. The store side expressed concern as follows.

- a. Increase risk of crime.
 - b. Take away parking space from shoppers.
 - c. P&R users are not customers of the store.
 - d. Increase in parking lot management fee.
-
- Share user initiative led by shared use P&R

The Pace Suburban Bus Service in Chicago wanted to use the parking lot of the commercial facility as a P&R facility, but the bus company avoided negotiations with the large commercial facility directly because there is a high possibility that the usage fee of the parking lot will rise. However, bus

users made groups, negotiated with large commercial facilities' near the bus stop, and were permitted to use P&R at large commercial facilities parking lot as P&R. This commuter was originally a customer of this store, so the shop side did not ask for a parking lot fee.

- Shared use P&R in Japan

In Japan, the same form of P&R was born. "K Park" project began in Kanazawa City since 1996. The characteristic is that a nonstop bus runs from the suburbs of the city to the city center, and in cooperation with the shopping center around the bus stop, the parking lot of the commercial facility is used as a P&R parking lot. The P&R user pays the parking fee in the form of purchasing a gift certificate of 3000 yen a month. Regarding the number of current P&R parking lots, there are 319 parking spaces in 14 places. Besides that, shared use P&R is also carried out in Aeon Mall Ayakawa, Kagawa, Aeon Mall Nagoya Minato parking lot in Kagawa prefecture.

5.2.2 Shared use P&R in Fukuoka City

As we mentioned in chapter 4, in Fukuoka City, the Public Traffic Promotion Division of the City Planning Division has been working on social experiments from November 2012 in cooperation with large commercial facilities in the city, and is currently implementing Shared use P&R in collaboration with a total of eight shops. Among them, there are 6

stores under full-scale implementation (Konoha Mall Hashimoto, Aeon Mall Kashiihama, Aeon Mall Fukuoka Ito, Aeon Mall Chikushino, Aeon Karatsu Shopping Center, and Aeon Mall Fukutsu). Aeon Mall Fukushige and Aeon Shima Shopping Center are at the stage of social experiments. Regarding the usage situation, each store started social experiments before the full-scale implementation. After confirming that there will be a certain number of users, the formal implementation will be carried out.

The following three points are necessary to use the parking lot.

- (1) Application form
- (2) Traffic IC card, commuter pass (city center: Tenjin / Hakata direction)
- (3) Purchase of AEON gift certificates, WAON charge card

The merit of each entity by implementing Shared use P&R is shown in the Fig. 5-2. For large commercial facilities, using empty space of large parking lot on weekdays by the implementation of Shared use P&R also increases income. Transport operators (high-speed buses, subways, etc.) will introduce P&R and passengers will increase, leading to increased revenues. For the administration, problems with the construction and operation of the parking lot are solved through collaboration with commercial facilities, and P&R implementation is also expected to promote commuting by public transportation, and it is expected to relieve traffic congestion in urban areas due to automobile commuting on weekdays.

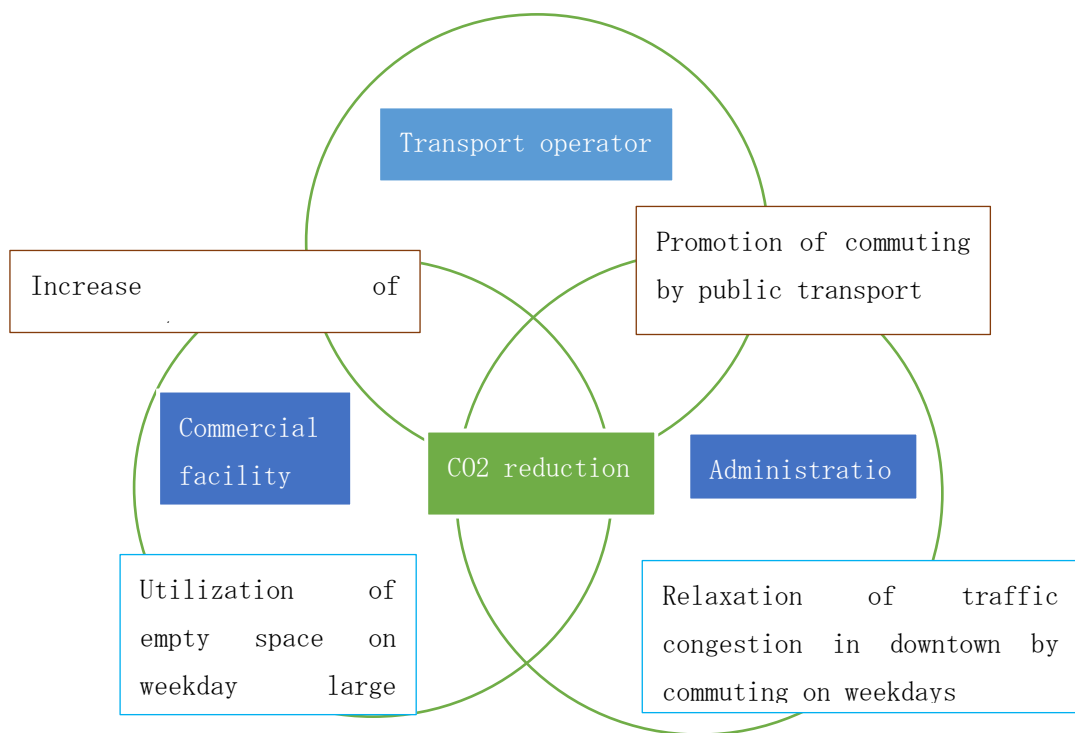


Fig.5- 2 Merit of each entity by implementation Shared use P&R

5.3 Comprehensive evaluation of Shared use P&R

According to the flowchart of Shared use P&R comprehensive

evaluation of Fig. 5-1, the evaluation method of each item is as follows.

5.3.1 Site selection

According to the reference, the method of analyzing the site selection in order to select the target shop is as follows.

(1) Extracting large parking lot suitable for implementation of P&R, using these facilities to compare traffic services (required time) with car commuters and P&R, and extracting P&R policy implementable areas.

(2) The extracted environment of P&R measures that can be implemented, using the number of car trips in the same area and the external environment (such as concluding a comprehensive collaboration agreement on regional cooperative work between administrative and commercial facilities) can evaluate the prior P&R execution area.

Comprehensive evaluation was conducted according to the scoring method (Table 5-1). The time lag between commuting by a car and P&R, the number of commuting trips, the share of automobiles to the city center, and the degree of external environment are rating items. The score of each mark is as follows: "○" = 2 points, "▲" = 1 point, "-" = 0 point. Since the external environment seems not to be an absolute element to determine P&R policy implementation feasibility compared with the required time

difference and commuting trip, "▲" = 1 point is the highest point. It is possible to score shops in each area and to determine the shop subject to prior execution.

Table 5- 1 Evaluation criteria of the priority implementation area

Score	time lag (car-P&R)	Commuting trips	Car Allocation Ratio	external environm ent	Store in Fukuoka city
○	Over 11 min.	Over 1000trips	Over 20%	-	-
▲	1~11 min.	Over 100trips	Over 10%	Applicabl e	Applicabl e
—	Less than 0 min.	Less than 100trips	Less than 10%	Not Applicabl e	Not Applicabl e

5.3.2 Public transportation service level

P&R measures are related to public transportation, and it is necessary to evaluate the level of public transportation services in the implementation area. Concerning public transportation service level, three points are considered with reference to consultation of Fukuoka city and Nishinohon Railway Co., Ltd.

- (1) Time lag between private car and public transport
- (2) The fastest transportation means of public transport
- (3) Frequency of public transportation

Scoring is shown in Table 5-2, which can evaluate the level of public transportation services in Shared use P&R executable shop area.

Table 5- 2 Evaluation criteria for public transportation service level

Analysis items	Score		
	3	2	1
To Tenjin (Time by car) — (Time by bus)	Over 4 min.	4~-3.8 min.	-3.8~-11.5 min.

To Hakata (Time by car) — (Time by bus)	Over 3.5 min.	3.5~7.7 min.	-7.7~-18.8 min.
Fastest public transportation to the city center	Railway Priority	Bus Priority	Transfer
Number of public transportation services	Over 615	615~337	337~120

5.3.3 Parking Status

Problems related to parking lots are mainly considered to be three factors, walking time from parking lot to bus station or railway station, parking lot capacity and parking fee. In the case of Shared use P&R, the parking fee is mostly in the form of purchase of gift certificates, so it is considered to be substantially equivalent to free. With reference to the number of parking lots of "Konoha Mall" which carried out Shared use P&R for the first time in Fukuoka City, about the walking time to the station and the parking lot capacity, referring to the station and the bus stop access walking distance, the parking capacity is over 1,000, the distance to the nearest station or bus stop shall be within 500m.

Regarding parking lot improvement, Fig. 5-3 shows the distribution map of AEON Mall Chikushino parking lot where P&R was fully implemented from September, in this case, a certain area is selected and used as a P&R parking lot on weekdays. A sign of P&R parking lot is established in the selected area. A user who contracts can manage even without a gate bar in the parking lot just by pasting the certificate on the car.



Fig.5- 3 Aeon Mall Chikushino P&R Parking lot

5.3.4 Estimation of the number of users

We conduct a questionnaire survey of the actual condition of commuting and intention to use Shared use P&R for commuters around the selected stores. The questionnaire results are analyzed and a transportation mode selection model is built. Using this model, the probable demand of P&R users at target stores before implementing policies is estimated.

5.3.5 Economic impact on commercial facilities

In order to obtain the cooperation of the selected stores, it is necessary to explain the economic impact. It is possible to calculate the income associated with the introduction of P&R according to the parking lot fee and the estimated number of users. Furthermore, by implementing Shared use P&R, we can also analyze changes in users' consumption patterns.

5.4 Case study

In order to verify the evaluation method in the previous section, a case study was conducted. We conducted a case study of the potential Shared use P&R for large commercial facilities in Fukuoka City.

5.4.1 Site selection

As mentioned in the previous section, large scale commercial facilities were evaluated by Fukuoka City. The results are shown in Table 5-3. Among them, the stores that did not introduce P&R are Sunlive Koga and IKEA Fukuoka Shingu. When comparing the points, Sunlive Koga is 5 points and IKEA Fukuoka Shingu is 3 points. Sunlive Koga with the high score is selected as the target shop. In Koga city, the distance from the store to the city center is about 20 km, and the population in 2015 was about 58,000.

Table 5- 3 Evaluation of priority implementation area by store area

Store	Time lag	Commuting trips	Car Allocation Ratio	External environment	Store in Fukuoka city	Comprehensive evaluation
Aeon Mall Kashiihama	▲	○ (2709T/Day)	○ (25.4%)	▲	▲	◎ (7)
Konoha Mall Hashimoto	▲	○ (4309T/Day)	▲ (19.2%)	-	▲	▲ (5)
Aeon Mall Fukuoka Ito	○	○ (1966T/Day)	▲ (16.1%)	▲	▲	◎ (7)
Aeon Mall Chikushino	○	▲ (332T/Day)	— (7.7%)	▲	-	▲ (4)
Aeon Onojo SC	○	○ (1550T/Day)	▲ (13.4%)	▲	-	◎(6)
Youme Town Munakata	▲	▲ (339T/Day)	▲ (17.6%)	-	-	▲(3)
Sunlive Koga	▲	▲ (661T/Day)	○ (25.4%)	-	-	▲ (4)
Aeon Mall Fukutsu	▲	▲ (663T/Day)	○ (21.4%)	▲	-	▲ (5)
IKEA Fukuoka Shingu	-	▲ (410T/Day)	○ (20.3%)	-	-	▲(3)

5.4.2 Public transportation service level

The railway is the main means of public transportation to the city center in Sunlive Koga's shop area (Fig.5-4). Table 5-4 shows the evaluation results of service levels of public transportation. In terms of the time difference between the car and public transportation, P&R can save less than 10 minutes when heading to the Tenjin area, P&R can save more than 10 minutes if heading to the Hakata station area. At the Koga station, the number of trucks running on the JR Kagoshima Main Line Hakata is 120 in weekdays.

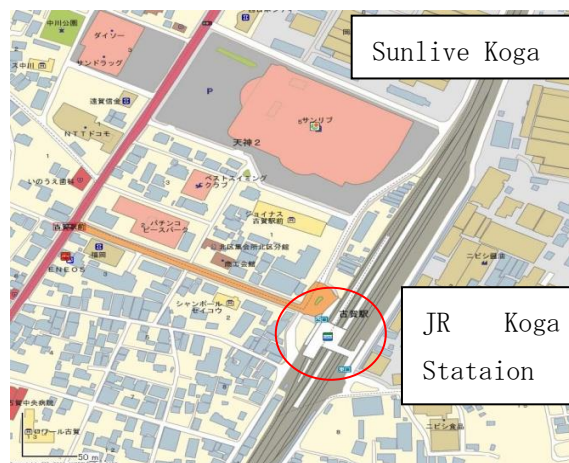


Fig.5- 4 Priority public transportation method of Sunlive Koga

Table 5- 4 Public transportation service level around Sunlive Koga

Analysis item	Result	Score
To Tenjin Time lag between car and P&R	Less than 10 min.	3
To Hakata Time lag between car and P&R	More than 10 min.	3
The fastest mean of transportation to the city center	Railway Priority	3
Traffic number of public transportation	120	1

5.4.3 Parking Status

As shown in Fig. 5-4, the distance from Sunlive Koga to the nearest station is 200 m, and the parking capacity is 1,400. According to the evaluation standard of the parking lot mentioned in the previous section, Sunlive Koga satisfies the installation condition of P&R parking lot.

5.4.4 Estimation of the number of users

In order to estimate the number of P&R users, we conducted a questionnaire survey on commuters around the selected stores. As shown in Table 5-5, the contents of the questionnaire can be divided into personal attributes, commuting situation and intention to use P&R.

Regarding the implementation of the questionnaire survey, on September 19, 2017, 2000 survey slips were distributed to the surveyed houses for the areas far from the Koga station, and then collected by mail. The recovery rate was 15% (299/2000).

Among the collected questionnaires, the percentage of commuters (Fig.5-5) is 47% (141 people). Among commuters, the car ownership rate (Fig.5-6) is 82%. In commuting mode of transportation (Fig.5-7), more than half of commuters commute by car.

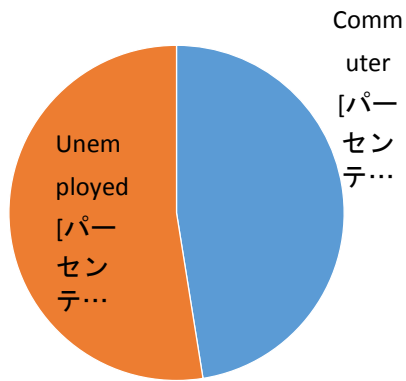


Fig.5- 5 Percentage of commuters

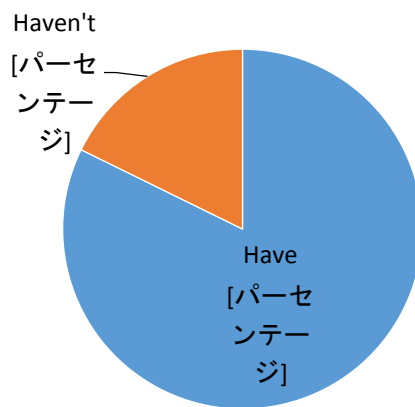


Fig.5- 6 Car ownership situation of commuters

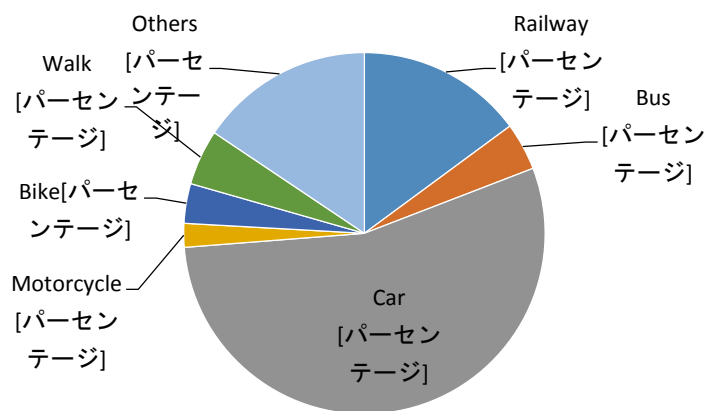


Fig.5- 7 Percentage of traffic mode

According to the results of the questionnaire survey of commuters, the number of valid responses after the exclusion of invalid samples due to lack of data is 71. The main summary analysis between P&R and factors is shown in Table 5-5. According to Table 5-5, in the personal attribute / household attribute, it can be understood that the intention to use of women is higher than that of men, and the lower the annual household income is, the more intense the intention will be to use P&R.

In terms of traffic conditions, the longer the commute distance is, the more intense the intention will be to use P&R, and for transportation methods, the automobile users are more willing to use P&R than public transport users. The number of commuters with a frequency of less than 4 times / week is small, but the proportion of intention to use P&R is higher and the frequency of commuting is lower. If commuting time is short and commuting costs are low, then people tend to use P&R.

As factors (variables) may affect the choice of using P&R, in addition to personal attributes, commuting distance, time, cost, transfer resistance may also be considered. Disaggregate model analysis of the samples is performed, but a satisfactory model could not be created from parameters and statistical significance. Therefore, among the attributes shown in Table 6, the samples are classified into 4 categories based on gender and annual household income, and have a clear relationship with the intentions to use

P&R, and we try to create a logit model that uses commuting conditions as variables in each group.

Table 5- 5 Result of primary summation

Factor	Rank	Intention to use P&R		
		Have	Haven't	Total
Sex	Male	16	22	38
	Female	18	15	33
Age	Under 30	7	5	12
	30~40	4	12	16
	40~50	11	9	20
	Over 50	12	11	23
Household income	Less than 5000000 Yen	15	14	29
	5000000~10000000 Yen	16	20	36
	More than 10000000 Yen	3	3	6
Distance	Less than 10km	19	16	35
	10~20km	3	2	5
	More than 20km	12	19	31
Traffic mode	Railway/Bus	10	12	22
	Car	24	25	49
Frequency	Less than 4 Times/Week	9	7	16
	More than 5Times/Week	25	30	55
Cost	~5000 Yen	16	15	31
	5000~10000 Yen	10	5	15
	10000~15000 Yen	2	8	10
	15000 Yen~	6	9	15
Commuting allowance	Have	27	28	55
	Haven't	7	9	16
Time	Less than 30 min.	21	19	40
	30 Min.~1Hour	11	13	24
	More than 1 Hour	2	5	7
Total		34	37	71

Transportation which can be considered as an option is a binary choice of P&R and other traffic modes. Using the binomial logit model, the probability P_{in} that individual n selects transportation means i is:

$$P_{in} = \frac{e^{V_{in}}}{e^{V_{1n}} + e^{V_{2n}}} \quad (1)$$

Here, V_{in} is a definite term of the utility by selection i , and if it is represented by a linear function, it becomes expression (2).

$$V_{in} = \beta_i X_{in} \quad (2)$$

At this time, the parameter β_i represents the importance given to the utility by the variable X_{in} .

As a result, the model using two variables of commuting distance and monthly commuting cost satisfied the positive/negative sign condition and statistical significance in all four groups, so we decided to adopt it. The transfer resistance was the same as that of the traffic mode dummy, and the traffic mode dummy was added for calculating, but the t value was low and was not used. The results are shown in Table 5-6. The number of groups is male · 5 million or less (S_1, I_1), female · 5 million or less (S_2, I_1), male · 5 million ~ 10 million yen (S_1, I_2), female · 5 million ~ 10 million yen (S_2, I_2).

Considering the result of parameter estimation, P&R selection of male commuters is influenced by commuting distance, and in the case of female

commuters, it is strongly affected by commuting expenses than commuting distance. Shared use P&R is a form of purchase of a gift certificate of a commercial facility and can be used for shopping, so it is considered more attractive for women. By using the model, when introducing P&R into Sunlive Koga, the ratio of P&R users in each group was calculated. The calculation results are shown in Table 5-7.

Table 5- 6 Estimated result of commuting distance and commuting fee

Variable	Parameter value			
	Commuting distance (km)	Monthly commuting fee (Yen / month)	Constant term	Coefficient of determination R ²
S ₁ 、 I ₁	-0.01408 ^(***)	-1.75E-05 ^(***)	0.627	0.283
S ₂ 、 I ₁	-0.00600 ^(**)	-2.1E-05 ^(***)	0.577	0.198
S ₁ 、 I ₂	-0.00379 ^(***)	-1.4E-06 ^(***)	0.472	0.344
S ₂ 、 I ₂	-0.00033 ^(***)	-9.5E-06 ^(***)	0.588	0.304

Table 5- 7 Rate to switch to P&R

Group classification	The number of samples	Percentage of P&R users
Male / household annual income less than 5 million yen	12	52.9%
Female / household annual income less than 5 million yen	15	50%
Male / household income Annual income 5 - 10 million yen	21	34.6%
Female / household income Annual income 5 - 10 million yen	16	52.3%

Since the number of residents around Sunlive Koga is 7,760, we calculated the number of people commuting by Shared use P&R, the commuting rate of male and female obtained through questionnaires, the percentage of annual household income by sex, and the estimated value of this model. The number of P&R parking lots is 60, which is equivalent to approximately 4% ($60/1,400$) of the number of parking lots accommodated.

5.4.5 Economic impact on commercial facilities

Referring to the monthly purchase price of gift certificates of shops conducting P&R shown in Table 4-1 in chapter 4, Shared use P&R gift certificate amount of Sunlive Koga is set at 5000 yen a month. This amount is multiplied by 60 users calculated in the previous section. The sales revenue of gift certificates due to the introduction of P&R will be 300,000 yen/month.

5.5 Summary

In this research, we defined P&R in commercial facilities as Shared use P&R. Through the previous chapter, we learned that the store has many doubts about the introduction of P&R and the negotiation between government and commercial facility was not easy. In order to allow the government to negotiate with the shop smoothly before implementing the policy, and making a reference method for the new introduction of Shared use P&R policy in other areas, a comprehensive evaluation including the

selection of the target shop, public transport service level, parking lot situation and the estimation of the number of users is proposed.

With Fukuoka City as a case city, according to the site selection evaluation method, we selected Sunlive Koga as the target shop. Next, we evaluated the public transportation service level around selected stores. In addition, we checked the parking lot condition of the target shop with reference to the store that introduced P&R and decided whether it could be used as a P&R parking lot. Questionnaire survey was conducted on residents around Sunlive Koga. Based on the questionnaire result, disaggregate model analysis was carried out to construct a binomial logit model of P&R and other transportation methods. As factors (variables) may affect the choice of using P&R, in addition to personal attributes, commuting distance, time, cost, transfer resistance may also be considered. Disaggregate model analysis of the samples is performed, but a satisfactory model could not be created from parameters and statistical significance. Therefore, among the attributes, the samples are classified into 4 categories based on gender and annual household income, and have a clear relationship with the intentions to use P&R, and we try to create a logit model that uses commuting conditions as variables in each group. The grouping is male · 5 million or less (S_1, I_1), female · 5 million or less (S_2, I_1), male · 5 million ~ 10 million yen (S_1, I_2), female · 5 million ~ 10 million yen (S_2, I_2). Using estimation results of the model, we estimated the number of people who will use P&R in Sunlive Koga. According to the estimation

results, among the residents near the store, the number of people using Shared use P&R as commuting means is 60. Finally, using the estimated number of users, it is also possible to estimate that gift certificate sales revenue associated with the introduction of P&R will increase by 300,000 yen per month.

By introducing P&R, commercial facilities should consider not only the number of gift vouchers, but also the changes in user consumption habits. Research on this will be advanced in the future.

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Chapter 6

Conclusions and suggestion

6.1 Conclusions

In recent decades, P&R has been introduced in many countries as a method of TDM. There is much research on P&R, and there are still some problems that have not been studied. On the other hand, with the development of P&R, new types of P&R have been born. Under such circumstances, this paper selected the problems of these two types of P&R for analysis and discussion. The main contents of this dissertation are summarized as below.

First, chapter 1 introduced the background and the objective. It was indicated that the effect of P&R introduction on bus users and the approach to comprehensively evaluating potential shared use P&R were basic feature of this paper.

Second, chapter 2 reviewed the relevant research. The researches on P&R can be separated into five parts: the pricing and siting plan of P&R facilities; the benefit of P&R introduction; the traveler response to traffic modes; P&R in countries around the world and new types of P&R facilities. Through the review, we noticed the problems of P&R include car trips' increase in suburb areas; the effect on bus users and new types of P&R's problem. Based on these problems, we chose our research objects as two parts: the traditional P&R and the new type P&R.

Third, chapter 3 discussed the problem of traditional P&R: the effect of P&R introduction on bus users. From the estimation and data analysis, we can conclude that the introduction of P&R facilities will impact the operation of bus. Since the existing price of P&R parking fee is at a very low level, when P&R is introduced, people will choose the cheapest travel mode by the price-oriented method. Though car users are also significantly reduced, however, when the introduction of P&R facilities affects the operation of bus, it is possible for the bus company to abolish the route which is unprofitable. At the position of the residents who cannot drive a car, the only way of travel they can choose is walking. For the residents who live far away from the railway station, it is very inconvenient to walk to the railway station. To avoid the situation, we increased the price of P&R parking fee to find a balance situation which the bus user can remain at the normal level as the time when the P&R facility is not introduced. Finally, we found when the price of P&R is 1,526 yen/day in 10km area and 1,535

yen/day in 20km area, bus users are exactly at the normal level. On the other hand, we found that it is hard for all related stakeholders to cooperate to maintain the operation of the bus company. In response to this drawback, a new type of P&R may provide a solution.

Next, from chapter 4, we noticed that a new type of P&R which cooperate with commercial facilities or other public facilities has been introduced in some areas in both America and Japan. In America it is called Shared use P&R, on the other hand, similar type of P&R has been introduced in Japan, but it has not been treated as a new type of P&R and the executive has no concept about Shared use P&R. In this chapter, we referred to the overseas examples to introduce the concept of Shared use P&R and defined the P&R cooperating with commercial facilities as Shared use P&R. In order to clarify the implementation of shared use P&R, we conducted interviews and literature reviews and learned that there were many consultations before the implementation of shared use P&R, realizing that the implementation of shared use P&R requires multi-party cooperation and some problems in the agreement process.

Therefore, for the situation we learned in the previous chapter, we have studied the problems of P&R and realized that the government needs to conduct a comprehensively evaluation of Shared use P&R before negotiating with commercial facilities, and obtain the forecasted data of the number of users and then negotiate with commercial facilities, which may

make the negotiations go smoothly. In this chapter, we adopted a step-by-step comprehensive evaluation and verified by case study.

Finally, chapter 6 summarized the main contents in all chapters and concluded this dissertation.

6.2 Suggestions for further studies

In the present study, we have left several matters that must be clarified on the further studies. Both traditional P&R and shared use P&R have one problem that the public transport operators are in a passive position. In chapter 3, as one of the stakeholders, the public transport operators are not involved in P&R's pricing and siting issues. In chapter 4, although the related public transport operator participated in negotiation, at the beginning of the agreement, there is still no clear responsibility for them.

In addition, in chapter 5, with the introduction of P&R in commercial facilities, some people who were not used to shopping here chose to shop because they used the parking lot here. Therefore, changes affect the introduction of shared use P&R facilities for commercial facilities' income and the shared use P&R users' shopping habits should be explored in future studies.

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