

Research on Park-and-ride Behavior

Wei Wang Yin

Shanghai Maritime University, Shanghai, China.

18341329282@163.com

Abstract

With the expansion of city scale, the problem of urban traffic congestion is increasingly serious. In order to alleviate the urban traffic congestion, all the major cities are looking for ways to adapt to their own development characteristics. It has gradually become a consensus to alleviate congestion through traffic demand management, solve the "urban disease" with high-quality public transport, and lead urban development. Park-and-ride is an important strategy to solve the transfer link in bus travel. The use of parking and transfer facilities by commuters to transfer from small cars to public transport to avoid the mass influx of cars into the central area of the city is of positive significance to ease congestion and promote the development of public transport. By summarizing the research results of park-and-ride behavior both at home and abroad, and combining the experience of park-and-ride behavior at home and abroad, this paper summarizes and analyzes some Suggestions on park-and-ride behavior based on public transportation.

Keywords

Urban traffic; Traffic behavior; Park-and-ride; Public transport.

1. Introduction

In recent years, urban land continues to expand, urban development from the original central radiation to organized urban development, increasing the communication between urban areas, the holding of urban activities has seriously increased the traffic pressure in the central city. Due to the high housing price, high pollution and safety problems in the central area of the city, more and more people choose the life mode of "living in the periphery of the city and working in the downtown area". As a result, the vehicles entering the central area of the city will cause more congestion on the originally congested roads, resulting in greater vehicle delays, which will affect and restrict the development of modern cities.

As a traffic demand management strategy, Park and Ride (P+R) enables commuters to use the park-and-ride facilities to transfer from small cars to public transport, so as to expand the service scope of public transport and alleviate road congestion in central cities. Park-and-ride has achieved remarkable results in many cities such as Oxford, Cleveland and Singapore[1,2]. The park-and-ride behavior provides a new way to promote the utilization rate of public transport and support the traffic in big cities. Good park-and-ride behavior is a perfect combination of individual traffic and urban public transport, such as cars. Combining with China's development strategy of public transport, it has become an important method to relieve traffic pressure in big cities.

2. The form and development of park-and-ride

The As a group of transportation facilities, park-and-ride facilities enable travelers to switch between individual transportation and public transportation. In theory, potential park-and-ride facilities could include walking, bicycles, motorcycles, cars, commuter buses, buses, urban rail transit, and even

private jets and intercity trains. Depending on the service object and the location of parking facilities, park-and-ride can be divided into different forms.

According to functional positioning, Spillar R.J[3] divides parking and transferring into six categories, namely simple, Shared, parking and sharing points, suburban parking and transferring points, passenger transportation center and edge parking lot. According to the location of facilities, it is divided into four categories, namely suburban park-and-ride points, suburban park-and-ride points, interval-park-and-ride points and marginal park-and-ride points.

Vuchic[4] analyzed the survey data of park-and-ride in the United States and concluded that although the cost of park-and-ride is relatively high, it can ease the large number of cars entering the central area, which has positive significance for the development of public transport, and is a desirable urban traffic development model. Although public transport and individual transport have been developing in parallel for nearly a century, it was not until the beginning of this century that people realized that if cars were connected to public transport through parking facilities, the customization of cars and the advantages of mass transport could be combined to support urban traffic. This will be a reliable transport strategy to relieve the pressure in the city center and expand the accessibility of public transport. In recent years, the United States, with the development of cars as the center, has made great progress in promoting the development of public transportation through the practice of park-and-ride facilities.

Some cities in China are also trying to push park-and-ride systems. For example, Beijing and Shanghai respectively carried out the recent park-and-ride system planning in 2007[5]. In 2011, Chengdu also completed the medium - and long-term planning of park-and-ride system[6]. However, at present, Chinese cities still pay little attention to the construction of park-and-ride facilities, which is limited to a few cities with subway operation and the park-and-ride system based on subway, and lack of analysis and demonstration on the most common park-and-ride system based on bus. Although Chinese scholars have made abundant achievements in the research of park-and-ride, most of these works focus on theoretical analysis, planning methods or park-and-ride behavior, and few introduce the practical experience of foreign park-and-ride.

3. A theoretical study of park-and-ride behavior

The park-and-ride behavior includes the choice of park-and-ride modes, park-and-ride facilities, road paths and subway lines, etc. The study of park-and-ride behavior is of great significance to judge the efficiency of park-and-ride system.

At present, the analysis methods of park-and-ride behavior mainly include two types: "individual choice behavior analysis method" and "network equilibrium analysis method". "Individual choice behavior analysis" focuses on the factors affecting individual parking and transfer behavior and their distribution; "Network equilibrium analysis" focuses on revealing the behavior rules of park-and-ride and network performance under the network equilibrium state.

3.1 Individual choice behavior analysis

The individual choice behavior analysis method obtains the preference information of the respondents through scientific and reasonable questionnaire survey, and makes statistical induction to obtain the distribution law of the influencing factors of parking and transfer behavior. By evaluating the influence of each factor on the selection behavior (generally in the form of sequence), a certain form of selection behavior model can be calibrated according to the sampling survey theory. Therefore, this method can reveal the characteristics of individual park-and-ride behavior most directly. According to the different analysis factors, the relevant research can be divided into the following six parts.

3.1.1 Individual choice behavior analysis

Park-and-ride behavior is influenced by user characteristics, such as gender, income, age, etc. However, the research results around the world have not reached a unified conclusion, which should be caused by the differences in the form and function of park-and-ride systems. Nevertheless,

it is sufficient to conclude that user characteristics have an important influence on park-and-ride behavior.

3.1.2 Situational factors

Situational factors refer to the factors directly related to the trip, such as the reason for the user's trip, time, whether he or she carries luggage, whether or not he or she has a travel companion, and the weather conditions during the trip. In the survey of park-and-ride users in various countries, the vast majority of park-and-ride users in Britain, Portugal and Singapore travel for the purpose of commuting [7]. In the Netherlands, the majority of park-and-ride users travel for entertainment purposes. In addition, different weather, travel time, luggage weight and other situational factors also have certain influence on park-and-ride users, and some rules are revealed [8].

3.1.3 Park-and-ride facility attributes

The attributes of park-and-ride facilities also have a great influence on park-and-ride behavior. Oxford and York found that the location relationship between park-and-ride facilities and public transport facilities, the capacity of parking spaces and the safety of surrounding environment had a great influence on the utilization rate of park-and-ride facilities.

After a field survey of bus rapid transit stations in the bay area, Dr. Caroline J. Dier [9] discussed the quantitative relationship between park-and-ride facility location, capacity, etc., and bus sharing rate. David Merriman [10] made a comparative analysis on the number of parking facilities in the passenger flow of Chicago subway station, and concluded that each additional parking space would increase the number of subway passengers by 0.6-2.2. Foote [11] proposes the "probability of successful parking" to describe the influence of park-and-ride facility service level on user behavior. Other factors related to park-and-ride facilities include the parking fee and the ticket price of bus transfer.

3.1.4. Cohesion of public transport system

Palmer [12] pointed out that only when the running speed of public transportation after transfer is greater than the running speed of cars in the area, the park-and-ride facilities are sufficiently attractive to users. Therefore, the key to the successful operation of park-and-ride facilities is to vigorously develop public transport and greatly improve its operating efficiency.

3.1.5. Destination car accessibility

Based on surveys in Oxford and York, users are more likely to consider switching to public transport when parking is tight and expensive in the city centre. Therefore, measures to increase parking costs in the central area and to restrict the use of cars are among the most effective measures to improve the use efficiency of park-transfer [13].

3.2 Network equilibrium analysis

The network equilibrium analysis method combined with the network topology and the use of the facilities on the comprehensive analysis. Generally, the factors included in the analysis include traffic flow characteristics, such as congestion effect and queuing phenomenon. The traveler's choice behavior includes the choice of modes (car mode, park-and-ride mode, public transportation mode, etc.), route choice, facility choice and other travel behaviors, and the traffic flow distribution is carried out according to the user equilibrium criterion, so as to obtain the performance indexes of the system under the network equilibrium state. Compared with the network of single mode of travel, the park-and-ride traffic network is a multi-mode network, and its traveler travel behavior modeling is more complex. Huang Haijun research group [14] studied Logit stochastic equilibrium selection model of parking and transferring at the bottleneck. Yi Kunnan [15] described the behavior of park-and-ride choice based on hierarchical Logit model, and established a mathematical programming model equivalent to the stochastic user equilibrium condition.

Tan Z.J [16] investigated the influence of multi-mode traffic information system on park-and-ride behavior, proposed a park-and-ride selection model based on Probit, established a fixed point model

equivalent to the equilibrium condition of random users, and designed a heuristic algorithm to solve the problem. The effect of MTIS on network performance under different market share and congestion level is analyzed.

4. Park-and-ride planning

4.1 Application conditions

4.1.1. Public transport service level

Public transportation mainly includes buses, subways and light rail. The service level of public transportation directly affects the travel time and comfort of passengers after transfer. The supply of parking and transfer facilities is built on high-level public transportation. Only by providing fast and convenient public transportation and a comfortable transfer environment can the competitiveness of public transportation be improved to private transportation. At the same time, at the transfer end, it is also necessary to ensure that the capacity of public transportation can meet the demand, and provide a good degree of cleanliness to achieve a good replacement of public transportation services for car travel.

4.1.2. P&R facilities

The influence of park-and-ride facility characteristics on park-and-ride demand mainly includes the following five aspects: Accessibility, Economy, convenience, Comfort and Security. The better the accessibility of park-and-ride facilities and the reduced travel time, the more people will choose park-and-ride. Accessibility is mainly reflected in the traffic condition near the facility and the time of detour. If the traffic around the facility is congested, the detour time is too long, which will make the transfer less attractive. The quality of park-and-ride facilities also has an important impact on travelers. A good parking space will make travelers feel comfortable and safe when they transfer, including the safety of travelers' personal safety and the safety of parked vehicles. In addition, improving the economy, convenience, comfort and other factors of the facility will improve the competitiveness of P&R in the mode of travel.

4.1.3. Park-and-ride information service

Park-and-ride information service has an important impact on transfer behavior. It is of great significance to improve the efficiency and function of P&R system by providing travelers with timely and accurate service information and guiding more people to transfer. Parking information service includes parking information and transfer information. Parking information includes the parking information and utilization rate of P&R system, which can reduce the searching time of travelers and quickly find the most suitable parking location. Transfer information mainly provides information such as departure time, departure frequency, transfer platform and the location of P&R system. When transferers realize the convenience and convenience brought by the information service, they will be more willing to participate in the P&R system.

4.1.4. Coordinate urban development goals

Starting from the early stage of the formulation of the plan, it is necessary to make continuous policies and develop no sudden and large-scale changes in the traffic pattern, so that people can easily accept the gradually formed park-and-ride pattern. Because the central area is limited in land use, and building and environmental protection is one of the main objectives of the city, especially when the environment is directly related to the local economy, such as the city with tourism or cultural industry as the pillar. With the introduction of the central city road and parking supply restriction policy, it is easier to coordinate with the urban development goals, and the negative effect of mobile traffic accessibility may be further reduced.

4.2 Park-and-ride site selection principle

1). Maximize passenger flow: this is the primary purpose of the park-and-ride system to guide more private car owners to transfer to rail transit. Therefore, the site should be located at the edge of the

suburbs, the edge of the CBD or the first and last station of rail transit with high population density and high park-and-ride demand.

2). Cost minimization: it should be located in the peripheral area of the city where the land price is relatively low to reduce its construction and operation costs. The land resources of the city are very limited. Upgrading the existing parking lot in the suitable location can save a lot of money, and the temporary parking lot can be used on the unused land.

3). Transfer convenience: it should be close to the entrance and exit of the main bus facilities, and it is convenient for cars to enter, and it is convenient for transfer personnel to get off the bus and directly enter the bus system. On the one hand, the traffic accessibility of the passageway and the entrance is better to attract more park-and-ride users; on the other hand, the detour distance of cars before entering the park-and-ride facilities is reduced. The walking distance between park-and-ride facilities and public transport should be as short as possible. Excessive walking time will increase travel time and reduce facility utilization. The optimal transfer distance should be within 400 meters, and the maximum transfer distance should not exceed 600 meters.

4). The shortest time: to ensure that the location can make the parking transfer to the destination time is shorter than the self-driving travel time. When people travel, the first thing they should consider is how long it takes to reach the destination. The reduction of travel time will greatly increase the probability that private car owners choose to park and transfer, especially young people pay more attention to the reduction of travel time.

5). Combining policies: as a public resource, park-and-ride facilities should meet the requirements of the overall planning of the city, coordinate with the nature of the surrounding land and regional planning, and not negatively affect the original surrounding road network. Meanwhile, they should conform to the surrounding environment and not destroy the surrounding landscape.

4.3 The system design

4.3.1.park-and-ride privilege

Based on the park-and-ride policy, a charging strategy based on the principle of "park-and-ride privilege" should be developed to attract car users. Parking can be through the radio frequency card or non-contact IC card to achieve no parking payment. In order to avoid common parking behavior to enjoy preferential policies, we can adopt the strategy of receiving bus fare discount by parking record, or by bus record to enjoy discount parking and transfer fees. Providing top-up card service also enables users to avoid the trouble of paying cash every time.

4.3.2.Connect to the bus system

It can provide on-time bus service and free seats for the starting bus lines. Using appropriately sized buses increases the likelihood that passengers will find an empty seat; Set special bus lanes along the route to improve the travel speed; Adopt the operation plan of large station express, only set up the station in the main post dense area. At the same time, it can provide comfortable waiting environment and coffee, food, newspaper and other services for passengers waiting for public transportation.

4.3.3.Information services

Traffic information display board, online sites, consulting telephone and other multi-channel information services. Strengthen the intelligent management of P&R system, timely release of parking guidance information and collection of vehicle information in parking lots. Before entering the city, information signs should be erected to provide parking Spaces in nearby parking lots, or timely broadcast parking Spaces at various transfer points.

4.3.4.Price differential policy

To strengthen the parking management in the central area of the city, charge high parking fees for private cars entering the control area, and charge a small amount of parking fees for P&R parking lots or implement preferential transportation. Through the implementation of differential charge management between city center and P&R parking lot, to promote travelers to change their driving

mode and choose public transportation to travel, so as to reduce the number of cars entering the city center.

4.3.5. Strengthen P&R system construction

Improve intelligent systems such as monitoring, information guidance and information release in the parking lot. Strengthen the safety management of lighting, signal signs and facility safety. In addition to parking lots, bicycle transfer area design and barrier-free intelligent design should be added.

5. Conclusion

In this paper, the existing at home and abroad about parking transfer behavior was studied, and introduces its construction background, the effect of construction and Suggestions for the development of future scholars to park-and-ride system etc, after summarizing analysis it is concluded that some parking transfer behavior of public transportation, based on relevant advice, the purpose is to provide reference for the application of the park-and-ride. There is no doubt that the park-and-ride system based on bus can successfully attract part of the car users into the center to transfer to public transport.

References

- [1] Meek S. D., Ison S.G., and Enoch M. P. The role of park-and-ride based on bus in Britain: a historical review and review[J]. Shao ling, lu yongbo (trans.). Urban transportation, 2011,1: 01-72.
- [2] Bos Iona. Changing Seats: A Behavioral analysis of P&R use [D]. Netherlands: delft university of technology, 2004.
- [3] S Pillar R.J., A Comprehensive Planning and Design Manual for Park and Ride [M]. New York: Parsons Brinckhoff Inc., 2002.
- [4] Vuchic VR., Urban Transit Systems and Technology [M]. Hoboken, New Jersey, the USA: John Wiley & Sons, Inc. 2007, 39-41.
- [5] Yang Ming, Research on the planning of Beijing park-and-ride system [J]. Traffic and transportation, 2005(5): 17-19.
- [6] Chengdu institute of planning and design. Planning of comprehensive vehicle parking lots around chengdu city center [R]. Chengdu: chengdu planning bureau, 2011.
- [7] Parkhurst G.P, Stokes G. Park and ride in Oxford and York: report of surveys [R]. Economic & social research council, London, 1994.
- [8] Turnbull K.F. Effective use of Park-and-ride facilities [R]. NCHRP Synthesis Report Number 213, Transportation Research Board 1995.
- [9] Caroline J R., Transit-based smart Parking in the San Francisco Bay Area: an assessment of user demand and behavioral effects [C]. TRB2004 Annual Meeting CD-ROM, 2004.
- [10] David Merriman., How many Parking spaces does it take to create one additional transit passenger [J]. Regional Science and Urban Economics, 1998(28):565-584.
- [11] Foote P.J., CTA Weekday Park and Ride Users: A choice market with ridership growth potential [C]. Paper Accepted for Presentation at the 79th Transportation Research Board, Annual Meeting, Washington dc, 2002.
- [12] Palmer D.J., Developing a Parking Policy and how to use it effectively in a wider transport Policy [C]. Proceedings of the Chartered Institute of Transport in the United Kingdom, 1997, 6(3):11-33.
- [13] Fan wenbo. Experience and enlightenment of the development of park-and-ride in Oxford [J]. Journal of transportation and engineering information, 2013, 11(1): 40-46.
- [14] Tian qiong, huang haijun. Logit stochastic equilibrium selection model of parking and transferring at bottleneck [J]. Journal of management science, 2005, 8(1):1-6.
- [15] Yi kunnan, yu feifei. Park-and-ride behavior in urban transportation network. Systems engineering. 2006, 24(3): 35-39.

- [16]Tan Z.J., Li Z.C., Lam W.H.K., Sumalee Agaehai., Modelling the effects of multi-modal travler information systems[C]. The 7th International Conference of Eastern Asia Society for Transportation Studies, Dalian, 2007:469-478.