Factors Influencing the Demand of Park and Ride in Traffic Management: A Review

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Abstract - *Park and Ride is a traffic management strategy for the issue of urban traffic congestion. Park and Ride (P&R) system is included into the city's urban environment's transportation infrastructure. P&R is regarded as a crucial component of transportation design since it serves as an intermodal connection point between private automobiles and public transportation. Park-and-ride services (P&R services) are widely used as a component of total demand management in several nations. Despite the difficulty in locating parking spaces in city centers, P&R services located near peripheral public transport stops has shown to be progressive in reducing traffic congestion. The objective of this research is to study the factors influencing the choice rider's behavior towards using P&R services and review the demand of P&R system in traffic management. This study can provide policy makers with relevant data for future planning and growth of park-and-ride service.*

*Key Words***: Park and Ride, Traffic congestion, Intermodal connection point, Choice rider, traffic management.**

1.INTRODUCTION

A well-balanced and environmentally friendly transportation system is greatly influenced by transportation planning. Highway development boosted private vehicles and dominated on public transport in industrialized countries. The environmental consequences, such as noise and exhaust pollution, are escalating as the number of cars increases. Physical interference, obstruction, and jamming are additional consequences of these advancements. One of the main causes of air pollution is the transportation industry, which also consumes a lot of non-renewable resources like petroleum. The increasing growth of automobiles in cities not only worsens environmental conditions but also leads to social problems including bad health and traffic jams.

Due to these circumstances, strategies to reduce the number of passenger automobiles entering the city center are sought after and put into practice. The construction of Park and Ride (P&R) parking lots on the outskirts of cities is a common practice. They are made to make it possible for customers to mix private and public modes of transportation while traveling, hence minimising the amount of passenger automobiles entering the city center. P&R parking helps make city centers more easily accessible by transportation.

Fig-1: Standard park and ride sign in the United States

The P&R system is a collection of facilities placed across a city's urban area with the goal of creating a link point or modal interchange to move drivers of private vehicles to a more environmentally friendly mode of transportation, such public transportation. In other words, the limits of both private and public transportation are tightly related to the Park and Ride system. Those who commute everyday by private vehicle to their destination live in places outside the metropolitan core or where there are few or no direct connections to public transportation. The core business district (CBD), where they do daily activities like work or shopping, is typically their objective. Due to the heavy traffic in the urban area, the entire journey by private vehicle from the point of origin to the destination is uncomfortable. Due to the fact that the connection and accessibility of public transportation are much better in urban areas, the P&R system enables modal shift for users of private transportation to switch to the public transportation system. This paper aims to study and review literature works on P&R method in traffic management.

2. LITERATURE REVIEW

Significant amount of research work has been done on various aspects in the field of P&R parking like modelling P&R parking user behavior, study of factors impacting P&R parking choice, placement and capacity of P&R parking, and analysis of parking space usage. This review paper focusses on the aspect of on the factors influencing the demand of P&R in traffic management.

Based on a review of relevant literature, it can be inferred that logit models are frequently employed to simulate P&R parking users behavior. Using discrete modal selection, Karamychev and Reeven [1] investigated how P&R parking in The Netherlands affected the disruption of vehicle traffic. The findings of their study show that the decrease in traffic in the city centre (caused by the P&R parking construction) may attract individuals who have previously relied on public transportation to use a car to travel to the city centre. Additionally, they suggested that a decline in traffic in the city's core can be matched by a corresponding rise in traffic on the city's outskirts. Bos and Molin [2] presented a logit model that was based on the options provided to drivers, including P&R parking, personal vehicles, and other forms of public transportation. These findings show that methods taken to lessen the appeal of cars are more common than making the P&R parking the most alluring option through certain tactics.

Another topic explored in the discussion of P&R parking is modelling the actions of P&R parking customers. Sharma et al. [3] carried out research to comprehend the actions of P&R parking customers. Two polynomial logit models were created by them. The first presupposed that users would pick the most usable options. The users select the choice they find most useful after considering all of their options and perceiving the level of profit associated with each one. The second model made the assumption that users minimise losses in comparison to accessible alternatives while making decisions. The findings of this study suggest that consumers select P&R parking to reduce their trip time and expenses. The works of Qin et al. [4] who used decision field theory to create a model describing the psychological decision-making processes of travellers, can be included in this collection of works. Based on surveys, Zhao et al. [5] provided a polynomial logit model for calculating the likelihood of selecting a travel mode.

Similar research was done by He et al.[6], who also used surveys to try to determine what factors affected P&R parking use when travelling. They employed a binary logit model for this. According to the model's findings, higher monthly income and more years of driving experience are associated with less frequent use of P&R parking whereas parking rates and congested roads are associated with increased usage of P&R parking. He et al. [7] also constructed a utility function using survey data. According to

the findings of the research, the authors claimed that the preferences for using P&R parking are influenced to varying degrees by the personal qualities of automobile users, travel traits, and the environment.

In response, Webb and Khani [8] published research on the preferences of P&R parking users in a research work. In this study, the polynomial logit model, mixed logit model, and nested logit model were evaluated for their predictive power. Using the results of the research, Webb and Khani concluded that polynomial and mixed logit models accurately reflect P&R parking consumers' preferences. The findings of their study support the notion that users prefer to spend more time travelling than travelling long distances. A disaggregated model based on survey results was also given by Ying et al. [9] in a different piece of work. According to the findings, traffic jams, route awareness, and a scarcity of parking spaces are the key variables influencing how P&R parking users behave. Hole [10] also utilised the logit model, although it was a binomial model. Based on the results of the survey, characteristics that influence the choice of P&R parking as one of the travel factors were examined

Szarata [11] presented the findings of a research that used the Delphic approach to estimate the number of possible users of the P&R parking in . In his subsequent research, Szarata [12] presented a method for calculating the percentage of city trips that now use P&R parking as opposed to the initial mode of transportation. The outcomes of surveys conducted using the Delphi method served as the foundation for this methodology. The relationship between the variables influencing P&R parking choice and the intention to use parking was examined by Qin et al. [13] using structural equation modelling. The findings of the study conducted by Qin et al. suggest that poor traffic conditions are to blame for the use of P&R parking. More individuals choose P&R parking due to the excellent quality of service provided by this type of parking and the comfort level of using public transportation. On the other hand, Chen et al. [14] created a mobile application that aids P&R parking users in selecting appropriate spaces to park their cars. Chen et al. employed a multi-criteria decision-making model for this objective

Xianwei LIU et al. [15] investigated into the behaviors in typical Shanghai park and ride locations. The findings indicate that the cost benefit and time savings of park and rides are its main draws. The main deterrent for interviewees choosing park and ride is the hassle of the transition. Savings are what most people consider when deciding whether to choose P&R time. People are more likely to pick P&R when there is a reduction in time than when there is a reduction in expense. Zhi-Chun Li, et al. [16] used a variational inequality framework to formulate the multimodal network equilibrium problem. The results demonstrated a significant relationship between the network performance in terms of total realised travel

demand and social welfare gain and the parking charging level, the number of parking spaces supplied at the P&R site and in the CBD area, as well as the dispatching frequency and fare of metro line. The efficiency of a modified ASA solution process is illustrated using a numerical example by Ziqi Song et al. [17]. The findings demonstrate that the ideal design significantly increases net social value and motivates commuters to switch from driving to transit and P&R modes i.e how the best location and capacity of P&R parking encourage commuters to drive to public transportation while using P&R parking.

Shahi Taphsir Islam, et al [18]. explored the mode change behaviour of P&R users. The choosing behaviour of P&R users' mode changes is examined using survey data on P&R users at various Melbourne stations, parking lots, and bus terminals. In this study, the models for the driving mode with a reference P&R mode and the public transportation alone mode were estimated using multinomial logistic regression using SPSS. Using only public transportation increases the likelihood of doing so for the entirety of the trip, while using it only occasionally increases the likelihood of opting for P&R mode. According to the findings of this study, the variables affecting the selection of P&R parking travel are the amount of time spent travelling via P&R parking, the amount of time spent travelling overall, the mode of transportation, and any nearby parking fees. In the study proposed by Xinyuan Chen, et al. [19] in order to encourage people to pick P&R, this analysis takes into account two distance-based train fare discount programs. It is suggested to implement both a linear and a nonlinear distance-based train fare discount scheme. The use of distance-based P&R train fare pricing systems could effectively shift travel demand to the P&R mode and reduce traffic in the downtown region, according to numerical examples. The utilisation rate of P&R sites located far from the city centre could be efficiently increased by distance-based P&R fee schemes.
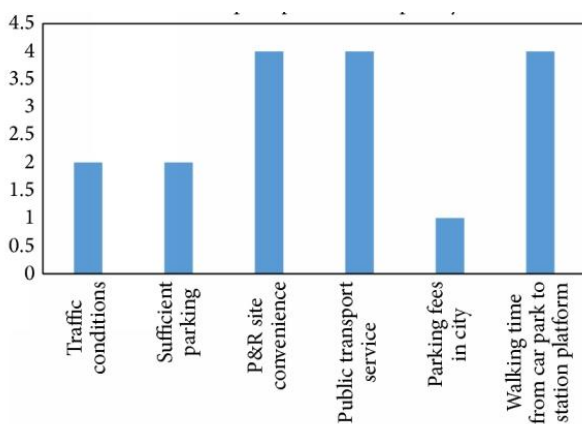

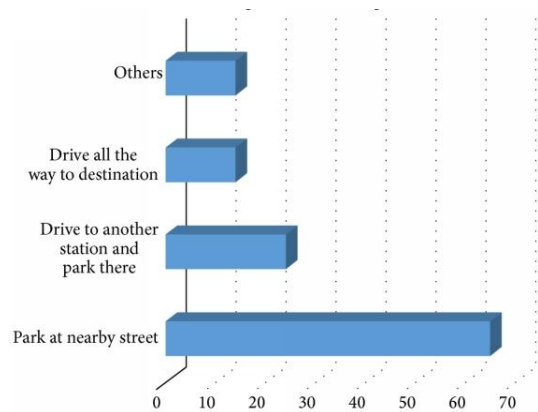**Fig-2:** Mode change behavior of P&R users [18]

Fig-3: Commuters decision for unavailable parking at P&R site[18]

According to Morrall and Bolger's [20] analysis, the availability of park-and-ride services has a significant influence on how often people use transportation in the city center, Its impact according to him is greater than impact of factors like reduction of traffic, improving access etc. Olaru et al [21] concluded in their study that if other forms of transportation are included in the P&R system, public transportation may also increase. In other words, bike parking, means of access, and time of day were the key determinants of selection for a particular facility. N. A. Hamid, et al [22] concluded that the introduction of a dedicated bus lane in the city centre will allow for an effective shift at the P&R service and will likely result in less travel time being required for P&R service. Additionally, using a park-and-ride service is necessary to save money and time compared to using another form of transportation.

Parkhurst [23] found that although park-and-ride services reduce urban congestion, they can increase peripheral urban vehicular traffic as drivers fail to make further journeys or attempt to access the facilities, or in some situations, switch from non-motorized to motorised travel. The effectiveness of commuter and ride-sharing services, the availability of incentives like high occupancy vehicle (HOV) priority, travellers' financial circumstances, and physical characteristics like the distribution of employment and jobs are all important factors. Magelund [24] investigated a number of variables that influence people's decision to use a car versus public transportation. Magelund excluded owning a car as a descriptive element in her model. As a result, it is calculated based on the other criteria. Her research shows that whereas money and factors connected to the workplace are substantially correlated, gender does not explain behavior. On the other side, the choice of transport mode is directly influenced by income and employment. The outcome demonstrates the importance of attitudes as a point of clarification. Low income and difficult parking at their workplaces are two factors that influence why people select public transportation. Although the research in the field of P&R is very limited in India, According to the studies done by

Aditya Manish Pitale et al.[25] decision riders have prioritised qualitative variables over quantitative factors like cost and time in the current setting. This suggests that customers who drive their own cars will only be drawn to the P&R if they receive services that are comparable to those they receive from their own cars. The findings of this study support the idea that choice riders would prefer a superior facility over one that is more affordable. If given a clean and safe setting, the respondents would prefer to employ P&R.

Krae E. Stieffenhofe et al. [26] proposed a methodology to assess the person-efficiency of parking spaces at these lots, measured as the passenger occupancy of parked vehicles. These findings support earlier hypotheses that the majority of parked cars were not full, and they offer scientific arguments for the use of parking management methods to increase parking efficiency. The estimations of person-efficiency from the audit were fairly accurate, according to a user intercept survey. The analysis also showed that the majority of people who parked at these locations did so for transit. Fixed-route transit predominated, however numerous lots saw substantial carpool/vanpool use as well. It will be necessary to take action to forbid these flexible transit uses if they are not desired. However, if these informal uses are prohibited at these lots, alternative space should be made available so that carpool/vanpool formations can still result.

Shahrbanoo Rezaei et al. [27] conducted a case study to understand the placement benefits of P&R facilities. In order to take into account probable commuter behaviour when arranging the amenities, demand and optimisation models were combined. Results of a case study conducted for the City of Nashville were discussed. According to the case study's findings, the placement of P&R facilities could enhance network efficiency and lower emissions and VKT.

Jamil Hamadneh et al. [28] in their research work studied how longer parking times at P&R facilities affect travel times. MATSim, an open-source programme, which employs co-evolutionary techniques, is used to run the simulation. The outcome confirms the overall findings of earlier research that the P&R system lengthens overall travel times. The link was not linear because it depends on a number of variables, including traveller location, P&R facility location, and potential time allotment for daily activity plans. According to the simulation, the average trip time increases by 5.75 minutes when parking at P&R facilities is increased from 3-6 to 10 minutes. The findings of this study inform policymakers and P&R operators about the significance of developing parking management techniques to cut down on time spent at P&R facilities, encourage automobile users to use the P&R system, and lessen traffic and pollution in the city centre. The study's findings support the idea that the P&R system's operational strategy affects travellers' mobility by using technology to cut down on time spent at the P&R facility.

Oleksii Lobashov et al. [29] conducted a case study of the city to obtain the demand characteristics for park and ride system in the Kharkiv. The results of their study indicated that despite a negative assessment of the urban trip efficiency, only 38% of drivers are ready to use park and ride lots under various conditions. The trip distance inside the city is used to determine the quantitative aspects of the distribution of transportation trips in the nodes of potential 'park and ride' lot locations. The demand for "park and ride" lots was segmented according to the frequency of trips to Kharkiv, the commute distance within the city, and the acceptability of the terms for using such parking lots as a result of the analysis of the objective data that was gathered. The results show that the "park and ride" demand is essentially nonexistent for distances of communication within the city of up to 5 km, and that the majority of the demand occurs for distances of communication outside the city of between 5 and 12 km.

Xinyuan CHEN et al. [30] developed a model which gives us access to the modal split and route preference patterns for the whole urban transport system, making it a very effective tool for assessing the potential performance of PNR and improving its design. In this research, stochastic travel time is taken into account along with CNL for modal split. With this advancement, it is anticipated that we will be able to achieve a more rational pattern for the mode and route selection of the urban transport system, which is essential for the planning and design of a PNR scheme in a city.

3. CONCLUSIONS

This paper has examined the usage of public transit via park-and-ride services, which is a well-known strategy to launching a sustainable transport agenda. Similarly, it elaborates on the factors impacting the use of park-and-ride services as a transportation demand management technique.

To give transportation researchers and planners a tool that can be customised to the city designs they are planning, this article contains the literature on the P&R system. There are cities where the system is already operational, some where it is planned to be deployed, others where it has already been fully implemented, and cities that are in the process of becoming smart cities. Planning for P&R systems should take into account emerging technologies like driverless and electrified automobiles.

The P&R system should be considered a mobility component that interacts with the various transport systems in the transport policies included in a city's SUMP but P&R shouldn't be seen as a distinct component of mobility.

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