

A literature review on the parking demand of park and ride facilities

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ABSTRACT: The increasing number of private vehicles in Malaysia has been inducing detrimental effects on the society in terms of increase in traffic congestion, noise and air pollution and accident casualties. Traffic congestion is a result of number of private car use exceeding the road capacity. Park and ride facility is recognized as an effective way in reducing the number of private car use especially at the central part of the urban areas. It is accomplished by providing adequate parking spaces with affordable parking charges at the park and ride facility to induce the shift from private cars to public transportation. The purpose of this paper is to analyse the parking utilization pattern at the park and ride facility and the factors influencing the demand for the park and ride facility based on data from literature review. The analysis includes determining characteristics of the park and ride facility, demand for park and ride facility and factors affecting the parking demand at the park and ride facility.

Key words: traffic congestion, park and ride, parking utilization, parking characteristics.

1. INTRODUCTION

An increasing number of population and high vehicle ownership in Malaysia has contributed to various transportation problems. The number of registered private cars has ascended from 6.5 million in 2005 to 8.5 million in 2009 [1] This is, particularly, due to the scenario since the early 1990s where some of the upper-middle income cities of the Asian countries such as Kuala Lumpur, Bangkok and Seoul had reached income levels that were then potentially able to support high rates of car and motorcycle ownership [2]. Armstrong-Wright [3]; and Vanconcellos [4] agreed that there would also be a greater propensity to travel when income had risen. In Malaysia, the increasing disposable income has made private motor vehicles more affordable, leading to increased demand [5]. Thus, the growth of motor vehicle has contributed to various negative effects including traffic congestion leading to increase in driver and passenger travel time and their associated costs, increased fuel consumption, air and noise pollution, as well as elevated accident and fatality rates. Hillman [6] agreed that the increase in car use generates congestion and can also affect the safety of other environmentally friendly modes, such as walking and cycling. Furthermore, Prabuwono and Idris [7] stated that an increase in car ownership, changes in traffic arrangements and densification of land has contributed to the diminishing supply of parking facility especially in the centre business district (CBD). Besides, as a result of increasing vehicle ownership, the problem is further aggravated by the decline in the use of public transport and occurrence of traffic congestion especially along the roads heading to the city centre.

One of the strategies that are widely applied towards countering such problem is the implementation of the park-and-ride scheme. Lam et al. [8] and Runkel [9] suggested that the implementation of the park and ride schemes has been viewed as part of the answer towards reducing congestion in the urban areas particularly that of the city centre. It is possible that park and ride can lead to more positive attitudes by car drivers towards public transport, thus possibly increasing levels of public transport use among car users [10]. Park and ride facilities are often introduced to expand the catchment area of public transport and to attract car commuters to more sustainable transport modes [11] [12].

Hence, the purpose of this paper is to analyse the parking utilization pattern at the park and ride facility and the factors influencing the demand for the park and ride facility based on data from literature

review. The analysis includes determining characteristics of the park and ride facility, demand for park and ride facility and factors affecting the parking demand at the park and ride facility.

2. LITERATURE REVIEW

2.1 Overview of Park and Ride Concept

Park-and-ride scheme is an integral component of many Transportation Demand Management (TDM) programs and can be further supported by the use of other TDM strategies such as reduction in parking spaces at the city centre area and control over its parking charges [13]. This scheme has been applied in many developed countries and cities as a means of transportation demand management and has achieved some results. Among the countries are North America, United Kingdom, Canada, and Hong Kong.

In defining the park and ride, Santos et al. [14] described park and ride facility as a parking space with good connections to the public transport network where car drivers can park their cars and use public transport for some parts of their journey and this combination of public and private transport enables multimodal transport use. Besides, the park and ride makes it possible for people to optimize their transport needs by using sustainable transport modes. In addition, Pickett and Gray [15] and O'Flaherty [16] both simply defines park and ride as the act of parking at a custom-built car park and transferring to public transport to travel onward to one's destination. Besides, park and ride can also be defined as providing a large number of low-cost parking facilities at rail transit stations at the outskirts of the city, so as to enable the car travelers to transfer into the public transport to the central area [17]. American Association of State Highway and Transportation Officials (AASHTO) [18] has generally defined them as a collection point for travelers to transfer between the auto mode and transit (bus or rail), or between the single occupant vehicles (SOV) and other high occupancy vehicles (HOV) such as vanpool or carpool modes.

Vincent and Mike [19] in their study provide an insight about the main objectives of park and ride policies is to transfer parking demand from the CBD to suburban or urban fringe locations to achieve the following benefits:

- Reducing traffic and congestion levels on urban radial routes and in the CBD itself
- Correspondingly reducing the need/pressure for increased road capacity and reducing emission levels, energy use and other environmental impacts.
- Reducing the amount of parking required in the CBD (where land is scarce and expensive and large car parks may be out of scale with the CBD townscape) and replacing it with parking in other locations (where land is cheaper and more readily available).

Furthermore, as described above, park and ride facilities are intended to persuade car drivers to use public transport instead of their car for the last part of their trips. Besides this goal, park and ride policies can have several other goals as listed below [20] [21].

- Improvement in the exploitation of the public transport through an increase in the number of users.
- Improvement in the quality of life of the inner city through the reduction in car traffic that reduces the emissions.
- Stimulation of economic growth in city centre through an improvement of the accessibility.
- Provision of additional or replacement of parking facilities.
- Improvement of the accessibility of the inner city by a reduction of car traffic [14].

2.2 Characteristics of Park and Ride Facility

Mingardo [21] identified three different types of park and ride scheme. Firstly, park and ride with origin functions that intercept car drivers at the start of the journey. The second types of park and ride is with a destination function that intercept car drivers at the end of their journey, while the last type of park and ride intercepts car drivers somewhere in between their origin and destination. Nevertheless, in terms of the classifications of the park and ride facilities, Turnbull [13] breaks down park and rides into locational, use and design categories. Under the locational category they are divided into:

- Remote - locations where the park and ride is relatively far from a major centre, usually offering a change of mode for residents in outer suburban areas or satellite communities.
- Local - Park and rides situated at the end of localized bus routes or short rail lines near the CBD.
- Peripheral - Park and rides located near the edge of the CBD to intercept CBD bound traffic.

Moreover, under the category of use, Turnbull [13] suggested that they are divided into:

- Exclusive park and rides that are planned and designed specifically to service a transit function.

- A shared facility where parking offered by a shopping centre, educational facility, sports venue, etc., very near to a transit interchange may officially or un-officially operates as a park and ride.

Furthermore, Young-Jong [22], categorized the park and ride facilities under locational aspect by three main types of the facility namely urban type with average distance from the centre of the CBD of 15 km, mid-area type with 15 – 25 km and suburban type with over 25 km. Park and ride facilities are usually located along a key transportation corridor connecting travelers' origins and destinations. AASHTO [18] has identified a hierarchy of different types of park and ride facility based on their distance to the "destination market" (for example, a job or commercial center).The hierarchy as recognized by AASHTO is summarized in the table 1.

Table 1: Park and Ride Facilities by Distance to Destination Market

<i>Facility Type</i>	<i>Distance from Primary Destination</i>	<i>Characteristics</i>	<i>Public Investment</i>
Suburban Park and Ride Lots	4 to 30 miles	Intermodal or change of-mode service provided	Tend to be publicly funded but offer opportunities for joint ventures or privatization
Remote Long Distance Lots	40 to 80 miles	Intercity commuters served	Typically publicly funded
Local Urban Park and Ride Lots	1 to 4 miles	Fills gap between suburban market and central business district; informal, shared use, or opportunistic	Often publicly funded, but provide opportunities for private operation
Peripheral Park and Ride Lots	Located at edge or periphery of primary destination	Intercept travelers prior to activity center; satellite park and ride lot	Opportunities for private investment; public investment should be carefully evaluated

Source: AASHTO Guide for Park and Ride Facilities [18] (cited in Franklin County Park and Ride Study, [23])

Additionally, the characteristics of the park and ride facility also vary in terms of the operational aspects and design of the park and ride facility. The operational characteristics include parking fees, parking operation hours and public transport connection. While, design categories may vary according to the adequacy of parking provided, safety, road access, landscaping, shelters, pedestrian connections to the interchange, and support facilities like lighting and public telephones [13]. Parking fees can help generate needed revenue, but they can also discourage use, adding another out of pocket cost to users and additional inconvenience. The vast majority of both shared use and exclusive park and ride facilities do not charge a fee for parking [24]. One aspect that the park and ride and rail operator can learn from the Hong Kong [8] and other Western Europe cases [9] is where users are given discounts when traveling to the city centre by the park-and-ride facilities. This has proven to be effective in retaining the current users of the facility and repeated purchases have been observed. Basically, the important principles of the success of the park and ride facility is that access to the CBD via park and ride needs to be competitive with the use of the car for the whole trip in terms of perceived generalized costs including quality, reliability, comfort, travel time, and out-of-pocket costs.

Additionally, the other characteristics of the park and ride facility are that it generally attached with the good public transport connection. To ensure this, Franklin County Park and Ride Study [23] stated that a park and ride lot should be located near, and with easy access to a major transportation corridor and ideally along a public transit route. Besides, the timing of the public transport services should be closely matched with the schedule of the park and ride users in order to minimize the total time involved. In terms of design, park and ride facility should be planned with the adequate number of parking spaces to cater for demand from the commuters. According to Merriman, D. [25], an increase in the number of parking spaces is of great importance to the users in encouraging them to switch to public transit or HOV (high occupancy vehicle). The safety aspects of the park and ride facility should be adequately addressed. Stevens and Homburger [26] studied the use of park and ride sites by bus commuters and

concluded that passengers were concerned about safety at park and ride sites and placed a high value on shelters besides passengers wanted improved bus services including longer hours of service and adequate capacity. Andre et al. [27] mentioned that the most favorably perceived actions to improve station security involve placing an attendant or security guard at the station full-time while a higher end application of security system is the installation of the CCTV. Besides, the success of a park and ride lot also depends on the physical design of the lot that is attractive, safe, and comfortable for waiting.

In addition, Vincent and Mike [19] described the characteristics of the park and ride facility that may determine the successful of such facility. These characteristics include the appropriate car park sites, in terms of location and facilities design, separate public transport corridor, appropriate information and marketing of the scheme as well as adequate personal and car security at the park and ride site.

2.3 Demand for Park and Ride Facility

Norlida [28] studied the daily workday parking demand at the suburbs park and ride facility namely Shah Alam and Seremban railway stations. The findings showed that the facilities at both stations were well utilized. The findings on parking demand was attained based on the analysis of the parking utilization indices namely its utilization (occupancy rate), accumulation as well as the duration of the facility itself. Utilization here refers to the occupancy of the designated spaces within the facility and is calculated as the number of spaces occupied over the total number of spaces available [29]. Accumulation relates to the number of vehicles parked at a given time [29] while duration explains the total hours that the vehicles being parked at the facility. It is divided into short-term parking, mid-term parking and long term parking [29] [30].

The results of this study revealed that the overall utilization rate at Shah Alam railway station was 95.1% (a total of 135 parkers from 142 parking spaces) while Seremban was 97.5% (with a total of 198 parkers from 203 parking spaces). This situation showed that these two park and ride facilities were highly occupied that reflects high demand from the rail transit users during weekdays. It is mainly due to high demand for work trip purposes. The majority of the parking users (55.6%) at Shah Alam station (55.6%) were parked for more than 8 hours while the remaining 44.4% of the total users were parked less than 8 hours. However, the results on parking duration at Seremban station were contrasted with that of Shah Alam, where 81.8% of the users parked for more than 8 hours while only 18.2% of the total users were parked less than 8 hours. This is similar to the findings by Kwon [31], where 52.8% of the users at the Seoul Metropolitan Area (SMA) were long term parkers who parked, on an average, for about 8 hours per day. The high percentage of long term parkers showed that there exists keen interest to utilize the park and ride facility particularly among the work trip makers of the suburban population [28]. The high percentage of long term parkers indicates that there is demand for the park and ride facilities especially among the trip makers from suburban area. This is shown by the demand for long term parking at Seremban station which is higher as compared to Shah Alam station.

In addition, the study conducted at the park and ride facility in San Francisco Bay Area at California by Shirgaokar and Deakin [32] found that from the surveys conducted at 49 Caltrans owned park and ride lots in the region, 19 lots were at or approaching capacity that is 80% or more full, 13 lots at or over capacity where all spaces taken and cars parked on shoulders. Moreover, 11 lots were heavily used and another 19 lots were underused where they had less than 50% occupancy at midday. In addition, the observation provided information on why some of the lots were underused. The findings showed that the most of the lots were located away from the freeway and several blocks off the mainline transit route. Some were in isolated locations with no active land uses nearby. Some other common problems identified at most of the lots were lack of security patrols, and some showed clear sign of vandalism, no sidewalk access, lack of bus shelters and signage on transit and ridesharing services were minimal. Besides the occupancy survey, the parking users' survey results revealed that almost all commuters who worked full-time were using the same park-and-ride lot for four or more days a week. Many park-and-ride users also were early travelers to ensure the availability of a parking space in the park-and-ride lots, but for many other workers, the early start was necessary due to the long distances that they need to travel.

Furthermore, Hamer [33] has studied on the demand of upgraded park and ride facilities in Melbourne, Australia. This survey was conducted at seven sites which grouped into three travel zones namely inner metropolitan, outer metropolitan and regional. The result revealed that park and ride plays an important role in Melbourne's public transport system where total number of parked cars exceeded the number of parking spaces by approximately 50% [34] with overflow parking can be found on local residential streets. Across all five metropolitan stations, car parking demand has increased by 21%, while public transport boarding increased by 13%. These results can be compared against the entire metropolitan

rail network where, between 2006 and 2008, car parking use has increased by an average of 9% per annum, while boarding increased by an average of 10% per annum [34] [35]. In 2008, the first seven car parking upgrades were opened, with the provision of additional 580 car parking spaces for commuters. Nevertheless, the provision of an additional 580 car parking spaces at these locations was found inadequate, thus requiring a further addition of 382 car parking spaces. It clearly indicates a huge demand on the park and ride facilities as the travel demand by the public transport were increased.

2.4 Factors Affecting the Parking Demand at the Park and Ride Facility

The value that users attach to park and ride depends on the characteristics of park and ride and personal factors such as age and purposes of the trip [36]. It determines that the socio-economic factors are among the factors affecting the parking demand at the park and ride facility. Some other variables such as income and gender are also involved in the socio-economic factors. Lam et al. [8] mentioned that the park and ride trial scheme in Hong Kong was accepted by car-owning middle income families because they were attracted by cost and time savings. In terms of gender, a study by Young-Jong [22] showed that 78.1% of the facility users were men as compared to 21.9% women users whereas study by CENTRO (West Midlands Passenger Transport Executive) found that most of the park and ride users were female. It showed that both male and female were interested to utilize park and ride facilities.

A 1981 United States survey found that the reasons for demand in park and ride facility were due to traffic congestion, parking costs at destination, trip costs, parking shortage at destination, trip length, and companionship [37]. In addition, Foote [38] showed mainly about CTA (Chicago Transit Authority) weekday users which found that the riders who chose park and ride primarily because it was the fastest way to make their trips, high parking cost at the destination, or they dislike driving. Ying, H. and H. Xiang [17] revealed that the most important reason why respondents had accepted park and ride was because of traffic congestion problem, lack of parking at destination and expensive parking fee. These findings showed that the "frequency of traffic congestion" leading to increase in travel time and cost has made commuters to utilize the park and ride facility.

Besides, the characteristics and service level of the public transport provided also affected the parking demand at the park and ride facility. Ying and Xiang [17] showed that among the evaluation indicators of park and ride service levels, the respondents were mainly concerned about "travel time in transit vehicle" (34%), "walking time" (26%), "waiting time" (24%) and "comfort in transit vehicle" (16 %). Moreover, Muhammad Nazri Borhan et. al [39] found that the majority of the park and ride users (74%) in Putrajaya agreed to use park and ride facility continuously if the frequency of the buses would reduced from every 30 minutes to every ten minutes. Hongzhi Guan [40], through the stated preference data, indicates that the parking fee, commute time and public transport fare were important factors to determine whether to use public transport or not.

It is undeniable that, appropriate planning for park and ride facilities can encourage shifts from single occupancy vehicles (SOV) to high occupancy vehicles (HOV) [41]. Therefore, the spatial factor is also another important variable that can affect the parking demand at the park and ride facility. The strategic location of the park and ride facility is essential to be considered. It is to determine the distance that the users, within the catchment area, need to commute to the park and ride facility and also from park and ride facility to the CBD. Catchment area is an important consideration, as there is a maximum acceptable distance involved beyond which the users are not willing to use a park and ride facility. O'Flaherty [16] mentioned that the common locational errors involved with both rail and bus-based park and ride are the location of interchange that is very close to the central area. Edwards J.D. [42] stated that rail based parking lots were found to have the greatest usage in the range between 8km and 24km from the CBD. Whereas, in terms of the average distance from the catchment area to the park and ride facility, the CENTRO study noted that its average distance was 4.4 km with an observed pattern that the distance driven to the facility tends to increase when the facility is located further from the city centre, although no direct relationship can be found. Over 50% of the respondents came from within 3 kilometres [43].

The parking characteristics such as parking availability, parking fees and parking design were found to influence parking demand at the park and ride facility. The number of parking spaces should be adequate for the conveniences and satisfaction of the parking users whenever they use park and ride facility. Additionally, it saves total travel time which is an important indicator for the high utilization of park and ride facility. On the safety aspect, Muhammad Nazri Borhan et al. [39] has revealed that about 54% of the respondents were strongly agreed to use park-and-ride facility if they were guaranteed with

car security at park and ride station and 94% of the respondents agreed that the security when using the public transport is the important element to attract them to use park-and-ride facility. Moreover, based on the findings from the survey conducted by Horowitz and Thompson [44], the first priority at transfer facilities was security and safety. In addition the study by Shayer [45] also divulges that transit users have considered safety as an important factor, and they would not make a trip if they feel the security level is inadequate. It indicates that the safety aspect is an important factor for the users to utilize park and ride facility and boarding the public transport. The safety level of the park and ride facility can be enhanced by the provision of the ample lighting, security guard, and CCTV. Parking fee is another important factor for the increase use of park and ride facility. O' Flaherty [16] agreed with both Niblett and Palmer [46] and pointed out that there is ample experience to suggest that parking at the interchange should be either very cheap or even preferably free to encourage parking users to utilize park and ride facility.

Moreover, "accessibility" is also considered as a significant factor that need to be looked into when planning park and ride facility for the purpose of increasing the demand from the users. The road connection from the origin of the users towards the park and ride should be well connected. Frequency of congestion on these connections should be minimized to make the facility fast and easily accessible and the road connections should be able to handle an increase in car traffic caused by the park and ride facility. Furthermore, easy access also implicates that road signage towards the park and ride is developed; people that use the park and ride for the first time should have no difficulty in finding the area [21]; [36].

3. CONCLUSIONS

Park and ride scheme is part of the Transport Demand Management (TDM) strategies to address the urban transport problems such as traffic congestions, insufficient parking space in city centre, road accidents, air and noise pollution. Park and ride facility is considered as a useful strategy which induces mode shift from private vehicle to more sustainable modes of transport namely public transport. Besides, park and ride facility has an important role to play in bringing public transport users to the station from the catchments beyond walking or cycling distance and reducing long car journeys by replacing them with multimodal car-rail journeys.

Several studies on the current parking demand at the selected park and ride facilities are highlighted in this paper and mostly it was found that the demand at the park and ride facilities was high. For instance, the high utilization rates at the Shah Alam and Seremban rail-based park and ride facilities showed the importance of park and ride facility in serving the commuters of the Klang valley. The characteristics of the park and ride facility such as types of park and ride facility, its strategic location would help to drive users within the catchment area to utilize park and ride facility. Various factors were found significant to increase the demand of the park and ride facility. Among the factors were; the availability of parking, location of parking, accessibility, types of parking, public transport schedule and services and more importantly public transport fare and parking fee.

This paper is an attempt to highlight on the literature related to the characteristics of the park and ride facility, parking demand at the park and ride facility and also the factors affecting the parking demand at the park and ride facility. The analysis of literature provided in this paper is expected to contribute towards understanding and potential of the park and ride facility in reducing the urban transportation problems.

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