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A study on the utilization of Park-and-Ride lots in South East Queensland

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Abstract

This paper describes the utilization of park-and-ride (PNR) lots in South East Queensland (SEQ). In the literature, utilization of PNR lots is generally taken as a static property. We consider utilization as a dynamic property of PNR lots and hence study utilization by conducting a survey of PNR lots for a period of time during a weekday morning. From the survey we collected data on the number of car arrivals and their arrival time. Utilization is measured as the ratio of usage (number of cars parked) of the PNR lot to its capacity. Also, information on the informal on-street parking was gathered wherever possible.

We designed and carried out the survey in 20 PNR lots of SEQ. The PNR lot survey began a few minutes prior to the arrival of the first public transport service near the PNR lot and ended when either the lot was fully occupied or there were very infrequent arrivals. For each arriving car, its arrival time within a 5-min interval was recorded. Results suggest that most of the PNR lots are filled or reach a steady arrival pattern by 9:30 am.

1. Introduction

Park and ride (PNR) is a common transit access mode. PNR allows users to connect with public transportation by providing facilities to park their cars. Users can leave their cars in these facilities and transfer to public transportation (bus, train etc). Similarly, kiss and ride (KNR) allows users to be dropped off by car to continue their remaining journey on public transport. PNR and KNR are incentives to promote public transportation. PNR or KNR is used whenever a car user decides that changing to public transport is advantageous to their journey in terms of time, cost or both (Dickins, 1991). PNR trips in which a transit trip follows a car trip is called access PNR and the reverse is called egress PNR. In access PNR a person is free to park at any desired lot with available capacity, whereas in egress PNR there is a constraint of returning to same place where the car was parked earlier.

PNR plays a vital role in maximizing the reach of transit to low density areas where users otherwise cannot access transit. Also, when car users change to PNR users there is a reduction in vehicle-kilometres of travel (VKT) (Turnbull et al., 2004). PNR helps reduce congestion in the central business district (CBD) by encouraging users to travel by transit inside the CBD while parking their car at the fringes of the CBD.

An emerging branch of PNR research is about dynamic PNR utilization. The attractiveness of PNR depends on the time of arrival at a PNR lot (Tsang et al., 2005).The later the arrival time to the lot, the lesser is the probability of getting a spot close to the platform; this lengthens the transfer time and hence, the lot is less attractive. This idea corresponds with another finding from (Arnott and Rowse, 1999), that parking lots in the morning peak are used in the order of increasing distance from the CBD. Further, talking about time of travel and user's travel behaviour, a study (Nurul Habib et al., 2012) identifies that there is a relation between parking type choice and the starting time of travel. For example, if users need to park their car for a longer time, they prefer the morning time to start their travel activities. Afternoon time caters to those activities that require lesser duration of parking.

Also, users with longer travel time requirements are likely to avoid travelling in the peak period. That study (Nurul Habib et al., 2012) can be taken as a reference for understanding interrelation between nature of parking choice and activity start time. However, that study addressed drive alone modes only. In his research on PNR lots in Kuala Lumpur, Hamid (2009) studied utilization, accumulation and duration. Utilization is considered to be the occupancy rate which is the ratio of number of car park spaces occupied to the number of available spaces. Accumulation is the number of vehicles parked at a given time, and duration is the total number of hour vehicles are parked in the facility. Both vehicles entering and exiting the facility were recorded throughout a day. Out of two PNR lots studied for the research, one shows active in-and-out flow of vehicles for 16 hours, whereas the other lot has active flow for 2 hours only and does not have continuous in-and-out flow. It is interesting to see that different PNR lots display different accumulation profiles.

Studies done of PNR lots in Perth, Australia suggest that parking lots are generally fully occupied before 7:30 am in most stations (Lin et al., 2014), and, in addition, the time by which parking capacity is reached is trending earlier and earlier (Chen et al., 2014). Another research study (Deakin et al., 2009) in the San Francisco area which studied the effect of parking fees on PNR lot use found that the increase of parking fees pushed users' arrival times later in the morning.

In this research, we study the PNR usage pattern for lots in South East Queensland (SEQ) for different time of the day by conducting lot surveys at various lots.

1.1 Literature review on studies based on PNR surveys

Table 1 lists some of the studies that include surveys related to PNR. Table 1 specifically highlights those surveys which include a car arrival time survey, an occupancy/site survey, and/or a parking duration survey. Other surveys like user-non user interview surveys at platforms or parking lots, or home interview surveys, are not included in this summary. Also, the focus of the Table 1 is only on understanding the PNR surveys (data collection technique) used in our study and does not shed any light on the models that were developed or results that were obtained from their studies.

Table 1 Papers that use PNR survey

Lot/site survey:				
Chen et al. (2014)	Perth, Australia	Utilization survey and an intercept questionnaire Survey	4 PNR area	Car arrival / departure survey from 6 am to 9am
Hamer (2010)	Melbourne, Australia	Count survey, user survey	7 PNR lots	Count survey done twice in a single day; at 10 am and 2 pm The average of the counts is used
Deakin et al. (2009)	San Francisco Bay area, California, USA	License plate survey , mail-back survey and focus group survey	2 PNR lots	License plate survey done for 3 days both before and after the parking fees were introduced Survey done from 10 am to 12 am

Hamid (2009)	Kuala Lumpur, Malaysia	Utilization survey	2 PNR lots	A license plate survey done continuously for 18 hr starting from 5:30 am to 23:30 pm on a weekday at each lot
Shirgaokar and Deakin (2005)	San Francisco Bay area, California, USA	Occupancy survey, user survey and Focus group discussion	Occupancy survey in 49 PNR lots User survey in 35 PNR lots	In the occupancy survey, they record the number of spaces, occupancy, and conditions on and around the site
Foote (2000)	Chicago, USA	Count survey, License plate (or municipality sticker census) survey and user survey	15 PNR lots	The license plate survey was done to determine the best basis for sampling for the user survey

Among PNR lot surveys, many are limited to count surveys and occupancy surveys. Among those who conduct car arrival and duration survey (Chen et al., 2014), Hamid (2009), the number of PNR lots they have used have been limited.

Further, talking about the studies done in Australia, Hamer (2010) made a comparative study of seven PNR lots in Melbourne before and after their capacity expansion. Two types of survey were conducted: a count survey and an interview survey. The count survey was performed twice, once prior to the expansion of PNR facilities and a second time a year after the upgrades were done. The count of all cars parked in and around the selected stations was made twice in a single day, at 10 am and 2 pm. An in-person questionnaire was conducted at each upgraded station at the same time as the parking usage survey during the weekday AM peak. The questionnaires targeted users' travel mode before and after the car parks were upgraded. The results suggest that the demand for PNR exceeded parking supply at all surveyed locations. Even after the upgrade, the parking supply was not sufficient as the demand increased further. This study gives many insights on the PNR situation in Melbourne; however, as they counted cars only at two specific times of the day, it gives little information on the usage of the PNR lots for different times of the day.

In their study, (Wiseman et al., 2012) highlighted the disadvantages of PNR by studying the PNR activity in the Adelaide Entertainment Centre PNR facility situated on the fringes of the Adelaide CBD. They conducted an observational study on the PNR facility and a face-to-face questionnaire with PNR patrons. The observational study was performed on two days from 7 am to 9:30 am, a week prior to the face-to-face interviews. The face-to-face interview was performed on a single day from 7 am to 9 am. The paper presents the impacts the PNR facility has on three aspects: car interception, public transport abstraction and overall impact. For car interception, they found that 29.8% of users who previously travelled to the CBD by car were found to use PNR after the opening of the PNR facility. Talking about the public transport abstraction, it was found that prior to the PNR facility opening, 62.7% of users had made their entire journey to the city by bus or train, and with the opening of the PNR lot, it fell to just 3.1%. An interesting thing is that unlike other studies, in their study the PNR facility did not generate any new trips. Further, they found that people who used walk/cycle to the city started using PNR. Though these results are very interesting, as their study was based on only one PNR lot, generalization of the results can be risky.

Another study by Lin et al. (2014) in Perth examined the elderly's access to train stations, where they studied PNR as one of the modes of access alongside BNR (Bike and ride) and WNR (Walk and ride). They conducted an intercept survey at 3 train stations in Perth to get the perceptions of people (including elderly) on the accessibility to train stations. The perceived accessibility was found to be higher relatively than the measured accessibility.

Another study (Chen et al., 2014) on PNR in Perth developed a location-based service (LBS) application to provide PNR users with real time info on the best departure station, based on their current location and planned departure time. A weighted linear combination method was applied to determine the best location based on four criteria, namely (i) the availability of parking spaces at a chosen station, (ii) the travel time from the user's location to a target train station, (iii) the frequency of trains and (iv) the service quality of stations. In order to find the availability of parking spaces in the PNR facility, a fuzzy logic forecasting model was used; the data was obtained from a traffic flow survey conducted in PNR facilities. In those surveys, researchers stood in the entrance of the car park lot from 6:00am to 9:00am and recorded the time in which each car entered and left the car park for a period of 5 days. In total, 4 PNR lots were surveyed. Further, in order to understand the service quality of stations, an intercept survey was performed from 3 pm to 7 pm, where the questionnaire included questions on users' perception on the parking availability, travel time, train frequency, and service quality of the station.

Apart from Chen et al. (2013), there is no significant research on time dependent PNR utilization in Australia. Chen et al. (2013) studied four PNR lots over a set time, i.e., 6 am to 9 am, which is restrictive in analysing the utilization of a lot until it is filled. We study twenty PNR lots in South East Queensland (SEQ), with the start time being 5-10 minutes prior to the first public transport service from the lot and the end time being the time when the lots get full or car arrivals become very sporadic (almost no arrivals). Further, one of the issues associated with PNR lots is the surplus parking that spill over in adjacent areas. Hamer (2010) suggests that when there is limited availability of parking spaces at a PNR facility, drivers will simply park their vehicles in the nearby local streets. Hence, we aim to collect information on informal parking and kiss-and-ride (KNR) behaviour wherever possible.

2. Study area

South East Queensland is chosen as the study area. SEQ is home to approximately 3 million people. There are over 170 formal PNR facilities across SEQ, providing around 27,000 parking spaces including 21,500 spaces on the city rail network. The cost of construction and land comprises up to A$ 30,000 per space. Also, annual maintenance cost per space is A$ 250. Average utilization of PNR facility is around 80 percent, and 35 percent of the facilities are over capacity. It is interesting to note that Brisbane, one of the main cities of SEQ, has more PNR spaces per person than some of Australia's other big cities like Adelaide, Melbourne, Perth or Sydney (Government, 2014).

In the SEQ region, PNR surveys done by the Department of Transport and Main Roads (DTMR) prior to this survey measured the total cars parked at a given time of day and the total capacity of the PNR lot. However, the accumulation profile of the parking lot, the time at which a PNR lot reaches its capacity, and the peak hour for parking were not known. Also, a traveller's choice of parking spot within a PNR lot could not be inferred from earlier surveys.

3. PNR lot Survey

3.1. Outline of the survey

A park-and-ride (PNR) lot survey was performed at 20 PNR lots around South East Queensland (SEQ) in August 2015. August was chosen as it is commonly one of the appropriate months for transport data collection due to the absence of school holidays later in the month. The survey was conducted over two weeks on weekdays only, and each lot

was surveyed only once. The survey in each lot started 5-10 min prior to the arrival of first public transport service at/near the lot and ended either when the lot was completely full or there were no further cars coming in for a significantly long time. Surveyors stood near the entrances of the car park and recorded the number of cars entering in the lots and their arrival times. The first four digits of the license plate of each incoming car was recorded, in order to avoid double counting by another data collector. The use of first four digits instead of whole license plate number is to avoid the unique identification and maintain the privacy of the PNR users. The total number of car spaces occupied and the total spaces available in the lot were recorded at the end of the survey. These data give the value of utilization of the PNR lot; utilization is the ratio of usage of PNR lot (cars) to the capacity of the lot at given time.

To select the PNR lots for the survey, those lots which were seen to be more heavily utilized in the TMR PNR study (Government, 2014) were selected, with representation from all major radial travel into the CBD, representing different train lines and busways. Figure 1 presents the twenty PNR lots that were surveyed.

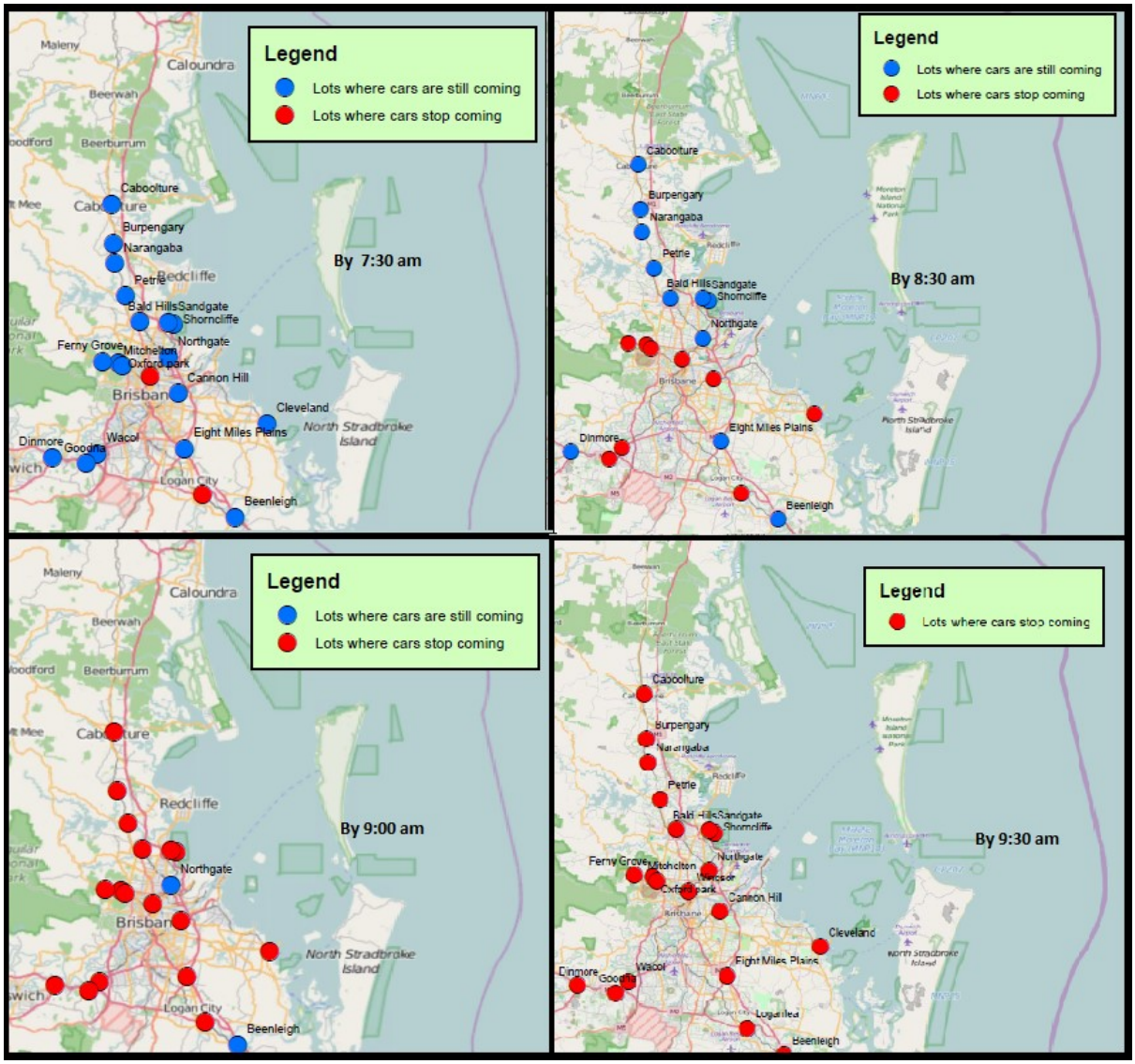
Figure 1 Selected PNR lots for the survey

The authors designed the survey framework and conducted a pilot survey at the parking lots of the University of Queensland prior to the actual survey at the PNR lots. In the pilot survey, the arrival time of cars approaching parking lot were recorded. In each survey location, 4-5 surveyors worked, depending on the number of entrances and the capacity of the lot.

4. Results

The end time of PNR survey was the time when the arrival of cars to the lot ended, either because the lot was full or because the lot reached more sporadic car arrivals (though some spaces were still remaining). When we analyze the ending time of the survey for all PNRs, as shown in Figure 2, we see that it does not necessarily follow the pattern seen in (Nurul Habib et al., 2012); notably, PNR lots in our study do not get filled in the order of increasing distance from the CBD.

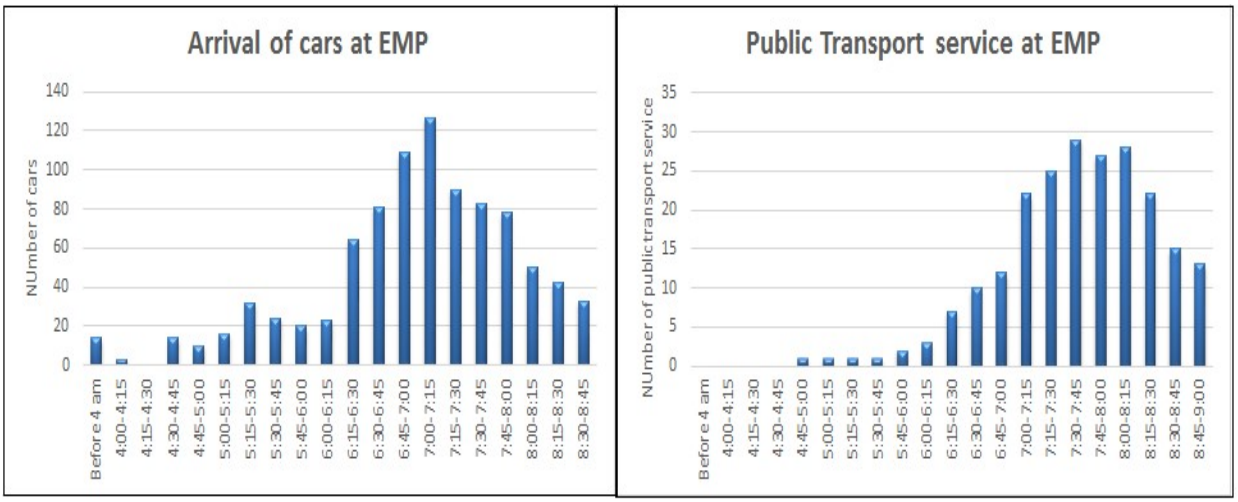
Figure 2 Survey closing time for different PNR lots



From all 20 PNR lots it is understood that car arrivals increase and reach a peak during the period when there is a high frequency of public transport service. For example, Eight Mile Plains (EMP) is one of the largest PNR lots, and it has no train service. The car arrivals and the public transport service at EMP are shown in Figure 3; where the y-axes represent the number of car arrivals and the number of public transport services. The public transport

service schedule was downloaded for the survey day from the Translink website (Translink, 2016).

Figure 3 Car arrival pattern and the public transport service at EMP

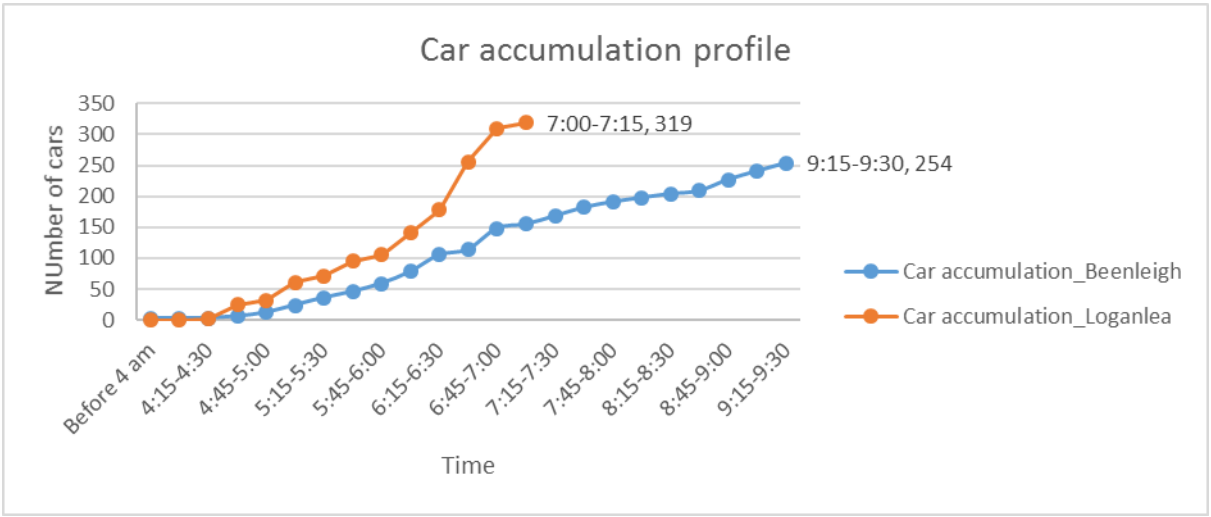


Studying both car arrivals and the public transport service together, it becomes clear that car arrivals in the PNR lot have a strong relationship with the public transport services. The car arrivals reach their peak during 7:00 am to 7:15 am. Likewise, there is a public transport service peak during 7:30 to 7:45 am. The difference of 15 minutes between the two peaks is as expected; PNR users come some minutes earlier to the PNR lots than the arrival time of the public transport service they intend to catch.

Though we started our survey 5-10 minutes prior to the first public transport service, in some of the PNR lots we found cars already parked before the commencement of our survey. These cars could be overnight parking, as PNR lots are free of cost, or it could be that someone parked there early in the morning to go elsewhere. We do not fully understand these details and simply name them as *parking before 4 am* in Figure 3.

Among the surveyed lots, Loganlea gets filled by as early as 7:15 am whereas Beenleigh fills up later, by 9:30 am. The car accumulation pattern of Loganlea and Beenleigh are shown in Figure 4.

Figure 4 Car accumulation at Loganlea and Beenleigh

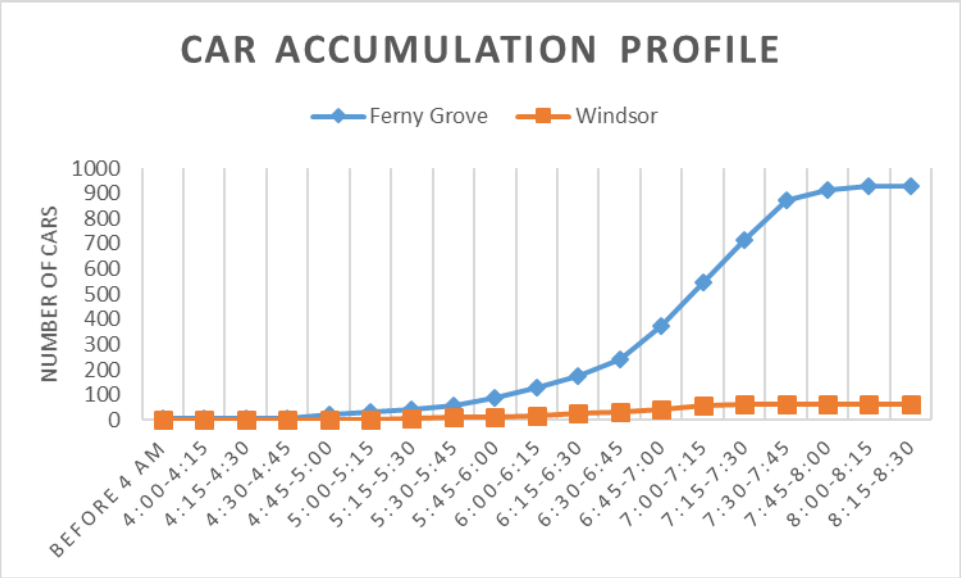


Loganlea and Beenleigh PNR lots both lie on the same train line. Looking at the public transport service from 4 am to 10 am, Logalea PNR lot serves 68 public transport services,

which is less than Beenleigh which serves 82 public transport services. From this we observe that users do not necessarily use a PNR lot only for the frequency of public transport services. The Loganlea station is closer to the CBD than Beenleigh, which might explain why its spaces fill faster compared to Beenleigh.

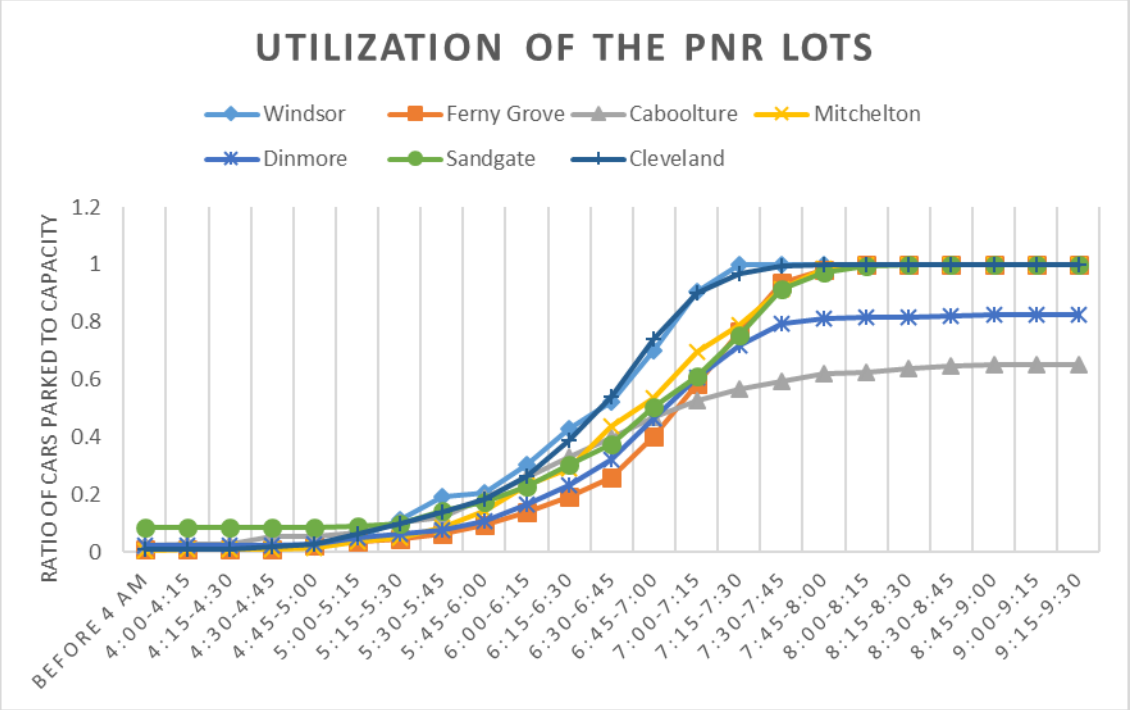
The smallest lot in our survey is Windsor with a capacity of 63 cars, and the largest lot is Ferny Grove with the capacity of 931 cars. The accumulation profile of Windsor and Ferny Grove are shown in **Figure 5**.

Figure 5 Car accumulation at Windsor and Ferny Grove



Windsor fills up by 7:30 am and Ferny Grove fills by 8:30 am. Windsor is the closest lot to the CBD among all surveyed lots. Further, the utilization of some other lots are presented in **Figure 6**; Caboolture and Dinmore are two PNR lots that did not reach capacity in the am peak. Both lots are fairly large; Caboolture has a total capacity of 675 spaces and Dinmore has 490 spaces. The remainder of the lots are utilized at 100 percent.

Figure 6 Temporal utilization of some PNR lots

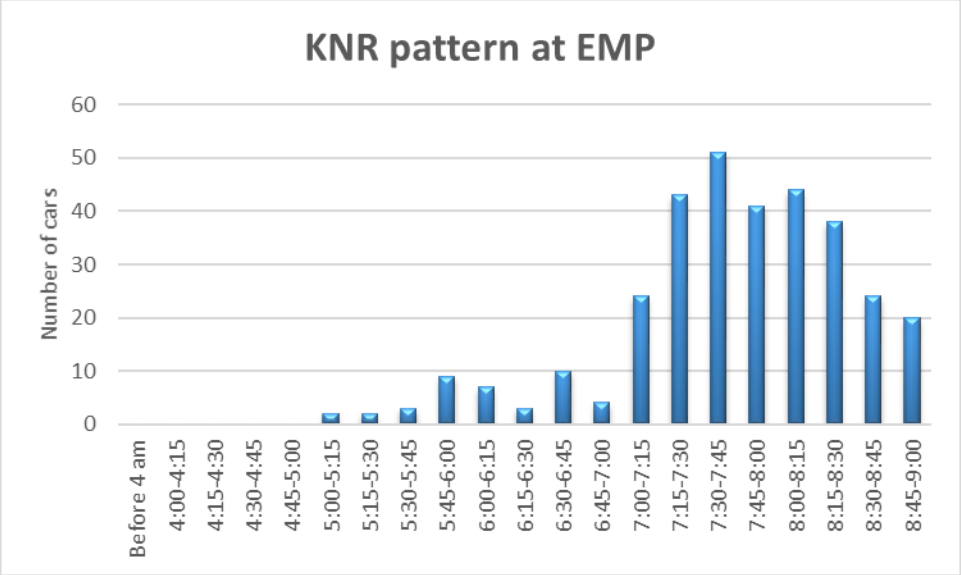


4.1. KNR and informal parking

KNR behavior and informal parking were recorded in lots whenever and wherever possible. Though we have ample data on these behaviours on many of the PNR lots, they are not exhaustive. While surveyors recorded a number of KNR users (drop offs) within the vicinity of the PNR lot, many people would be dropped off some distance to the lot. Our surveyors were spread out across entrances, but we did not have surveyors in entrances with footpaths only; people who are dropped off or walk access passengers could not be easily recorded. Similarly, surveyors made a note of informal parking in the adjacent streets, but informal parking could have happened in distant streets too, making it impossible for surveyors to fully account for them.

We have KNR information in some lots, EMP being one of them. In EMP, there is provision to drop off people just in front of the gate leading to the platform. For EMP, these recorded trips may not be the total KNR trips that happened in EMP. To provide some sense of the demand, the KNR trips at EMP are presented in Figure 7.

Figure 7 Number of KNR trips at EMP



KNR trips reach their peak at 7:30 am to 7:45 am, which is a little later than the time when the car arrivals in the PNR lot reach their peak, as shown in Figure 3, i.e., 7:00 am to 7:15 am. These results complement each other; people parking at PNR lots will come some minutes prior to their intended public transport service, when compared with KNR users who have less activity to do (like searching for parking or parking the car) and less distance to walk. Further, informal parking in SEQ has an interesting nature. Based on the observation study, it is found that people prefer to park on local streets (with no fees) than to park in PNR lots when the latter requires a longer walk.

5. Conclusion

We studied the utilization at twenty of the PNR lots in SEQ. It is interesting to observe how some PNR lots reach their capacity earlier in the morning while some fill later, regardless of their size and proximity to the CBD; rather, utilization of PNR lots differs for the different time of the morning period. This is the first study on time dependent PNR utilization in SEQ and provides a basis for further studies on PNR demand in SEQ. This study provides a good reference point for PNR planner to understand the dynamic nature of PNR demand. As a planner, knowledge of PNR demand is indispensable, to provide PNR supply that would meet the demand. Our study shows the need for further study on KNR behaviour and informal parking in and nearby the formal PNR lots.

6. Limitations

After the survey, we realized that our survey strategy could not fully accommodate KNR behaviour and informal parking. Further, if there were any outgoing vehicles during the survey period, they were not recorded; outgoing vehicles were beyond the scope of our study.

7. Acknowledgement

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