CAR AVAILABILITY: ACCOUNTING FOR TEMPORAL VARIATIONS

A. J. Richardson
Director, Transport Research Centre, RMIT University, Melbourne, Australia
&
E. S. Ampt
Associate, Steer Davies Gleave, London

Richardson, A.J. and Ampt, E.S. (1997). "Car Availability: Accounting for Temporal Variations", 25th PTRC European Transport Forum, Brunel University, England.

1. INTRODUCTION

Many models of travel demand, particularly models of mode choice, have assumed that the choice of mode is often highly constrained, with many users being captive to certain modes because of economic or social circumstances. In particular, many studies have noted that those people without access to a private car are the most predominant users of public transport, particularly in off-peak times. Other studies have also demonstrated the effects of access to cars on the total number of trips made, and concluded that lack of access to a private car is a prime determinant of "transport poverty".

However, most of these studies have defined "access to cars" in a rather simplified manner. Specifically, most studies have used "household car ownership" as the major measure of "access to cars", and have categorised households as "non-car-owning", "single car households", and "multiple car households" (e.g. Hensher, 1986; Sansom and Dawe 1996; de Jong, 1997). Some more advanced studies have considered the number of people in the household to obtain a "cars per person" ratio, and have used this measure to explain variations in trip generation and mode use.

This paper takes the view that "access to a car" should mean "was a car available to a particular person at the time when that person wanted to make a trip?". For example, if the family car is parked at a workplace during the day when someone at home wants to go shopping, then that person has no "access to a car" at that time. This paper uses data from the 1992 South-East Queensland Household Travel Survey (SEQHTS) and the 1994 Victorian Activity and Travel Survey (VATS) to calculate true measures of "access to a car" by tracing the location of household cars during the day and matching this with the travel demands expressed by members of the household.

The objective of the paper is to demonstrate the methods by which the various measures of "access to cars" can be calculated from home interview survey data, and to show that significant differences in understanding can be obtained from the use of these different measures of "access to cars".

2. DATA SOURCES

This data on which this paper is based comes from two major travel surveys conducted by the Transport Research Centre in the past few years; the 1992 South-East Queensland Household Travel Survey (SEQHTS) conducted for the Queensland Department of Transport (Richardson & Ampt, 1993a), and the 1994 Victorian Activity & Travel Survey (VATS) being conducted by the Transport Research Centre as part of the Victorian Integrated Travel, Activities & Land-Use (VITAL) toolkit project (Richardson & Ampt, 1993b). The SEQHTS and VATS surveys use a similar survey design and methodology, in that they were both conducted using a similar self-completion mailback questionnaire survey, which has been customised for the geographic region and the needs of the client. The survey obtains information on all trips by all modes of transport by all household members on a specific travel day for that household.

The SEQHTS survey was conducted in three areas of South-East Queensland; Brisbane, the Gold Coast and the Sunshine Coast. This paper uses results only from the Brisbane part of the survey. The surveys were conducted on weekdays over a two-week survey period in November 1992. The survey procedure included extensive follow-up procedures including telephone interviews with respondents to clarify data provided on the self-completion forms, personal interviews with a sample of responding households to check on the overall quality of data provided by the self-completion process, and personal interviews with a sample of non-responding households to check on the reasons for the non-response and to obtain information on the characteristics of the non-respondents. The Brisbane survey obtained a useable sample of 5800 households, resulting in a response rate of 73%.

The VATS survey is similar to the SEQHTS survey with respect to the telephone interview follow-ups and the validation and non-response interviews. However, the VATS survey is spread across all days of the year, thereby capturing the variations in travel behaviour across all days of the week and all weeks of the year. The survey commenced in December 1993, and is scheduled to run for five years, in the first instance. The data used in this paper covers the period December 1993 through June 1994. During this period a total of 5043 responding households were obtained from the Melbourne Statistical Division, at a response rate of 54%.

The SEQHTS and VATS surveys obtain information on the household characteristics, the vehicles garaged at the household, the demographic characteristics of the members of the household, and all trips made by household members. Importantly, for this study, each car trip recorded by the respondents includes an indication of which vehicle was used. As will be shown later, this feature of the data enables the calculation of more sophisticated measures of "access to cars" than has been possible in the past with conventional travel survey data.

3. CONVENTIONAL MEASURES OF CAR OWNERSHIP

Because of the nature of the data collected in the SEQHTS and VATS surveys, it is possible to calculate the conventional measures of "access to cars" and then compare them with the new measures. The two measures of car ownership discussed in this section of the paper are:

- number of cars per household
- number of cars per person

Within these definitions of car ownership, some specific aspects of car ownership will be highlighted, including:

- car ownership as a function of household size
- the incidence of access to company cars
- travel behaviour as a function of car household car ownership

3.1 Cars per Household

The most common measure of "access to cars" is the number of cars per household. It is usually assumed that a higher number of cars per household will have impacts on the travel behaviour of the residents of the household. Because the questions on car ownership were asked in exactly the same way in the SEQHTS and VATS surveys, it is possible to graph them together, as shown in Figure 1.

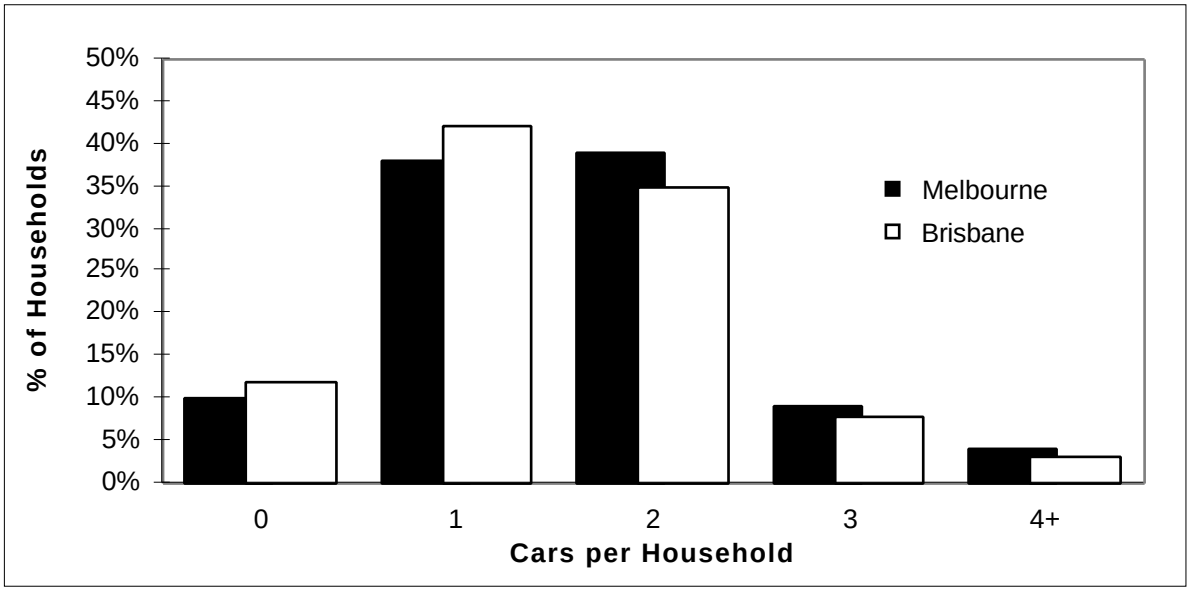

Figure 1 Household Car Ownership in Melbourne and Brisbane

It can be seen that in both Melbourne and Brisbane, the majority of households have one or two cars, with Melbourne having a slightly higher car ownership than Brisbane. Approximately 10-12% of households, however, have no car. The number of cars per household is highly related to the size of the household, with higher car ownership being associated with larger households, as shown in Figure 2.

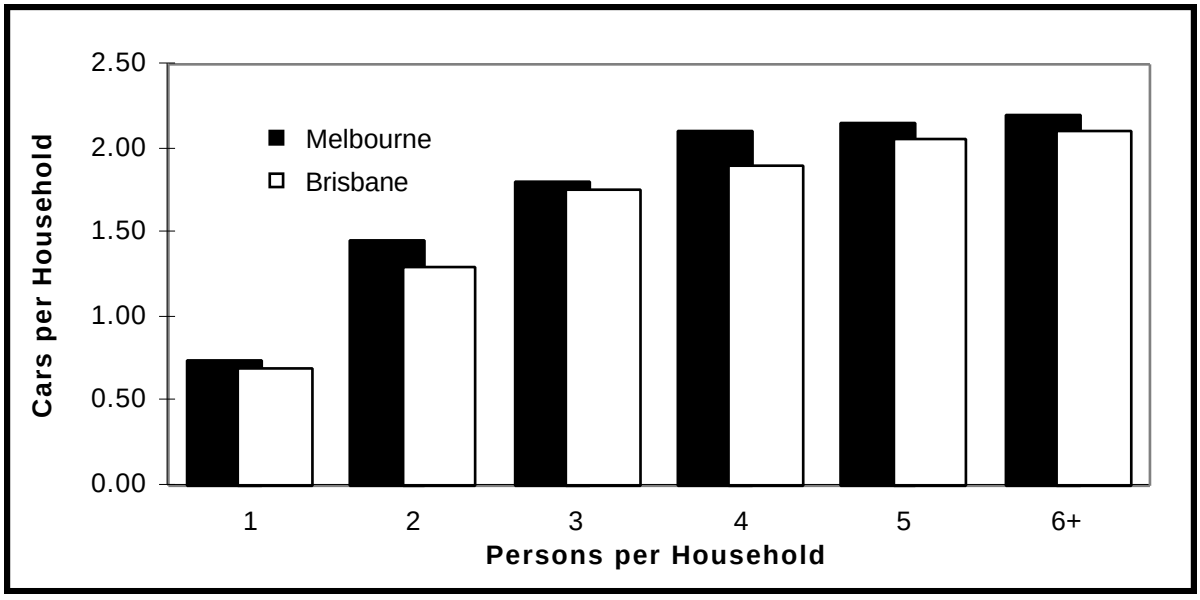

Figure 2 Household Car Ownership as a Function of Household Size

3.2 Access to Company Cars

Although Figures 1 and 2 refer to "car ownership", it should be realised that these car numbers include company cars, which are not owned by the household, but were garaged at the household on the night before the Travel Day. The percentage of all household-based cars which were company cars was 11% in both Brisbane and Melbourne. However, this figure tends to mask the true extent of the provision of company cars. The 11% figure is obtained as an average across cars of all ages. As shown in Figure 3, the bulk of the household-based fleet (in the early 1990s) in both Brisbane and Melbourne was manufactured in the mid-80s.

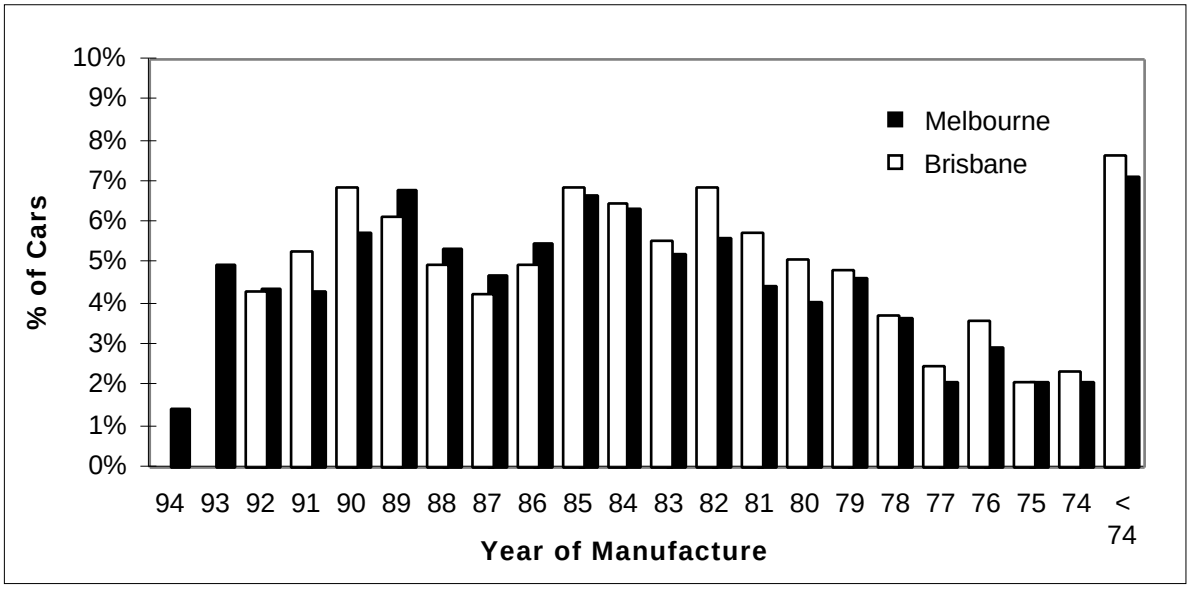

Figure 3 The Age Distribution of the Household-Based Car Fleet

It is known, however, that most company cars are relatively new, because the taxation advantages of trading-in company cars after a few years are quite persuasive. Indeed, Figure 4 shows that 45% of all new cars in households in Melbourne, and 33% of all new cars in households in Brisbane, are company cars. This would, however, underestimate the extent of purchase of new cars by companies because cars garaged at worksites are not included in the sample of cars considered in the SEQHTS and VATS surveys. While it may appear from Figure 4 that there has been a substantial increase in company cars in recent years, this is mostly illusory. It is not the case that few company cars were purchased five years ago; it is just that most of them would by now have been traded-in and would now be classified as private cars. While the average age of the total household-based car fleet is about 10 years, the average age of household-based company cars is only 4 years. The multi-year nature of the VATS survey will allow the tracking of developments in company car purchases over future years, especially if substantial changes in taxation arrangements are introduced. A more detailed exploration of the issues surrounding company cars can be found in Luk and Richardson (1997).

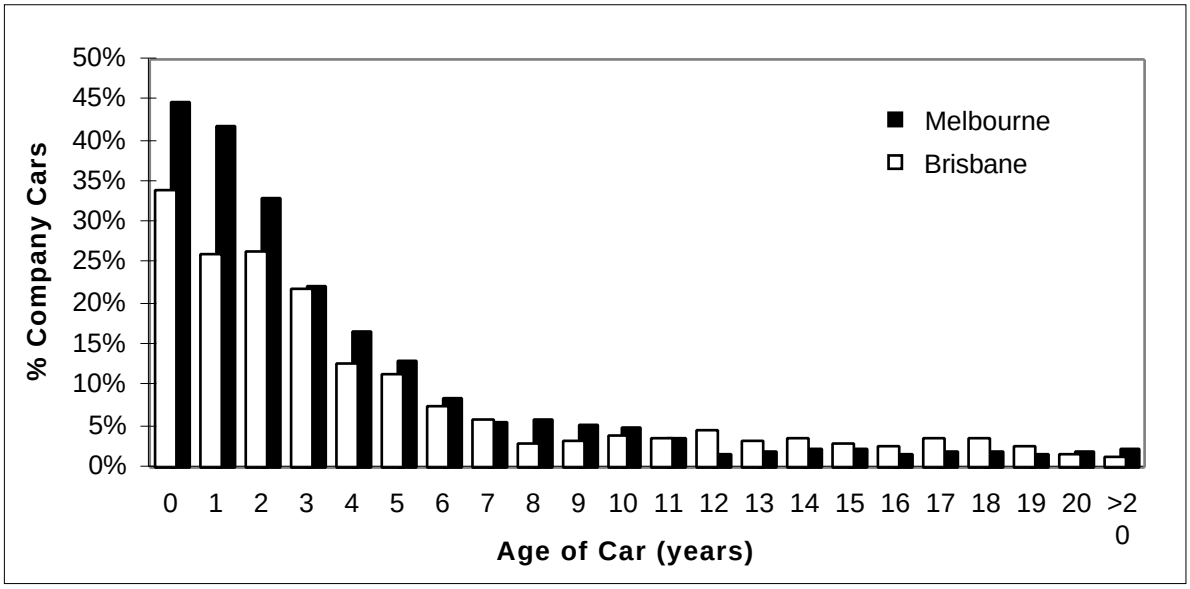

Figure 4 Percentage of Company Cars by Age of Car

3.3 Travel Behaviour as a Function of Car Ownership

One of the major reasons for interest in car ownership is that it has been shown to influence travel behaviour in various ways. Specifically, car ownership has been seen to be correlated with trip generation and mode choice decisions. Table 1 shows the average number of trips per household per day as a function of household size and household car ownership (for the Melbourne 1994 data).

Table 1 Household Trip Rates by Household Size and Car Ownership

Cars per Household	Persons per Household						
	1	2	3	4	5	6+	TOTAL
0	1.67	3.85	5.79	6.91	10.00	15.50	2.83
1	3.93	5.72	9.79	12.16	16.80	16.38	6.71
2	5.47	8.13	10.52	14.60	17.14	22.42	11.58
3	7.75	7.52	10.89	13.07	16.98	17.57	12.38
4+	—	13.88	11.08	16.43	17.97	18.50	16.37
TOTAL	3.25	6.68	10.16	13.84	16.98	19.59	8.80

Source: VATS 94

It can be seen that household trip rates increase, as expected, with increasing household size. However, within each household size, the trip rate independently increases with increases in car ownership. The overall variation in household trip rate with changes in car ownership is shown in Figure 5. It can be seen that household trip rate increases approximately lineally with increases in household car ownership.

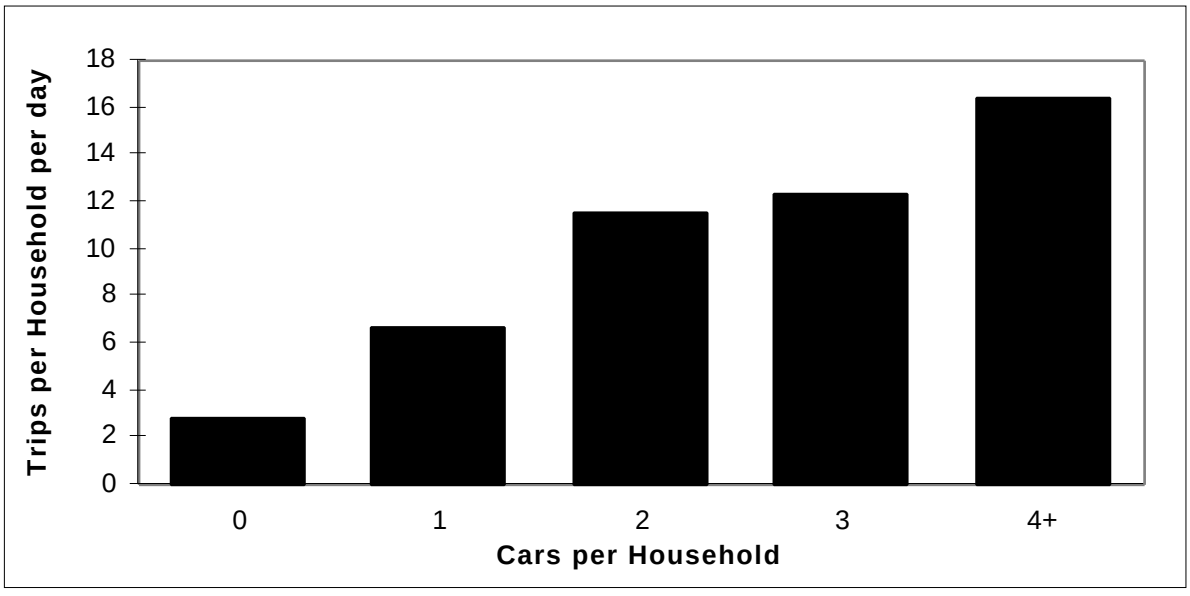

Figure 5 Household Trip Rate as a Function of Car Ownership

The effect of car ownership on mode choice for home-based trips on an average day in Melbourne 1994 is shown in Table 2. Overall, car driver trips account for 50% of all home-based trips, while car passenger trips account for another 26%. Non-motorised transport (walk and bicycle) accounts for the next largest number of trips (16%), while public transport (train, tram and bus) accounts for only 7%.

Table 2 Mode Split as a Function of Household Car Ownership

Cars per Household	Non-motorised	Car Driver	Car Passenger	Public Transport	Other
0	49%	1%	11%	35%	5%
1	20%	45%	25%	9%	1%
2	13%	53%	30%	4%	1%
3	8%	63%	21%	6%	1%
4+	6%	72%	16%	5%	1%
TOTAL	16%	50%	26%	7%	1%

Source: VATS 94

Households without cars, however, have substantially different mode usage. Trips by walk and bicycle account for almost half of the home-based trips in these households, while public transport accounts for 35% of all trips. Other modes, primarily taxi, account for 5%. Clearly, the absence of any car has a significant effect on the mode usage within these households. For households with at least one car, the mode choice still varies systematically (e.g. decreasing non-motorised transport with increasing car ownership), but the effect is not as great as the transition from no car to one car.

3.4 Cars per Person

All the above discussion of "access to cars" has been based on the use of the total car ownership in the household. However, it was seen in Figure 2 that car ownership and household size are strongly correlated; the more people in the household, the more cars in the household. Therefore, it may prove useful to obtain a better measure of the "access to cars" if the number of cars per person in the household was calculated. This would then distinguish between the case of a household with one car and four people and another household with one car and one person. Clearly, there would be less "access to cars" for the people in the first household than in the second. The impact of calculating car ownership in this way is clearly demonstrated in Figures 6 and 7, which show the regional variations in car ownership in Brisbane and Melbourne. It can be seen that while cars per household fluctuates substantially across the regions, with a tendency to increase in the outer regions (on the right of each graph), the cars per person is virtually identical in all areas of each city.

The lesson to be learned from Figures 6 and 7 is that the variations in car ownership across a city are primarily a function of differences in household size across the city. Inner-city residents own just as many cars per person as do people who live in the "urban sprawl" outer regions of the city. Clearly, however, adoption of a different definition of car ownership will again change this conclusion. Cars per licensed driver would probably find greater values in outer areas, because of the higher proportion of children in outer areas. It is this search for better definitions of "access to cars" which forms the central theme of the remainder of this paper.

4. TOWARDS BETTER MEASURES OF CAR AVAILABILITY

The first part of this paper has examined some conventional measures of car ownership, and found that they were usefully connected to various measures of travel behaviour. However, different conclusions could be drawn, depending on the definition of car ownership adopted. Behaviourally, car ownership affects travel behaviour, not because of any legal ownership of the car, but because that ownership allows the traveller to use the car for a particular trip. A better explanation than ownership, therefore, is one which relates to car "availability" for a particular trip. If the car is not available for a specific trip, then this is what will affect the characteristics of that trip.

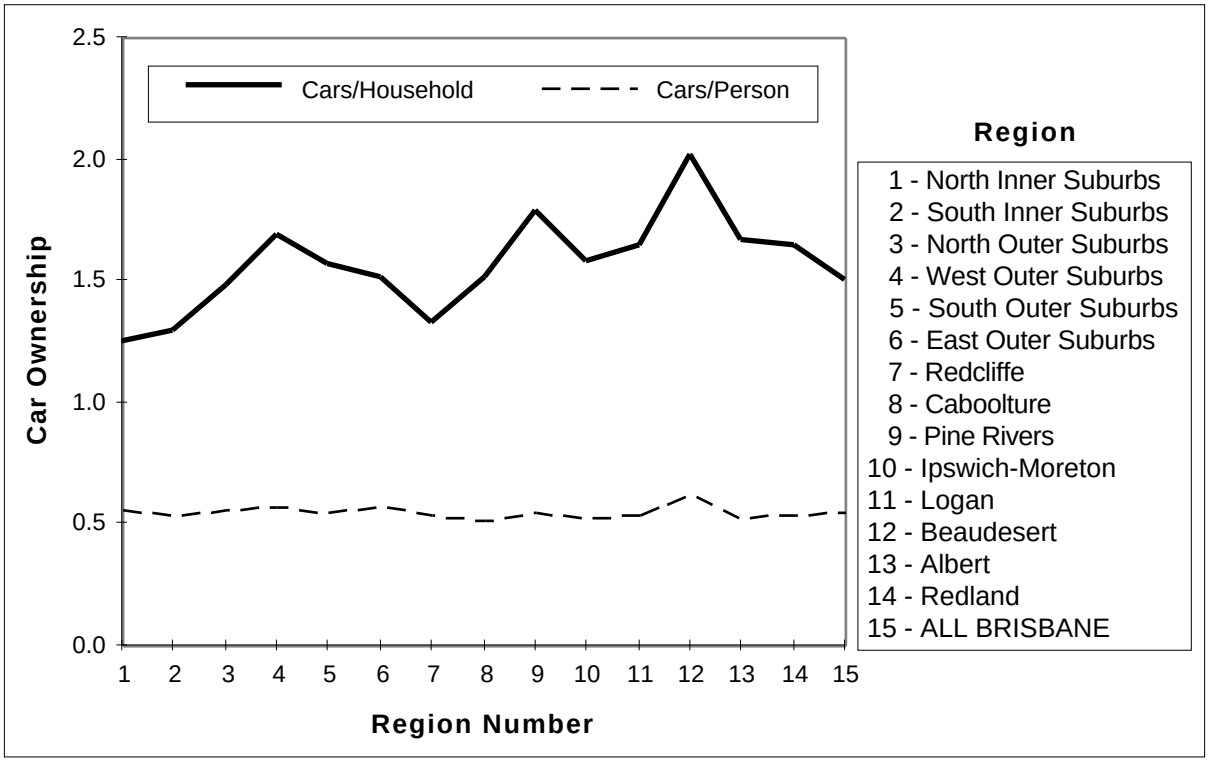

Figure 6 Car Ownership in Different Regions of Brisbane

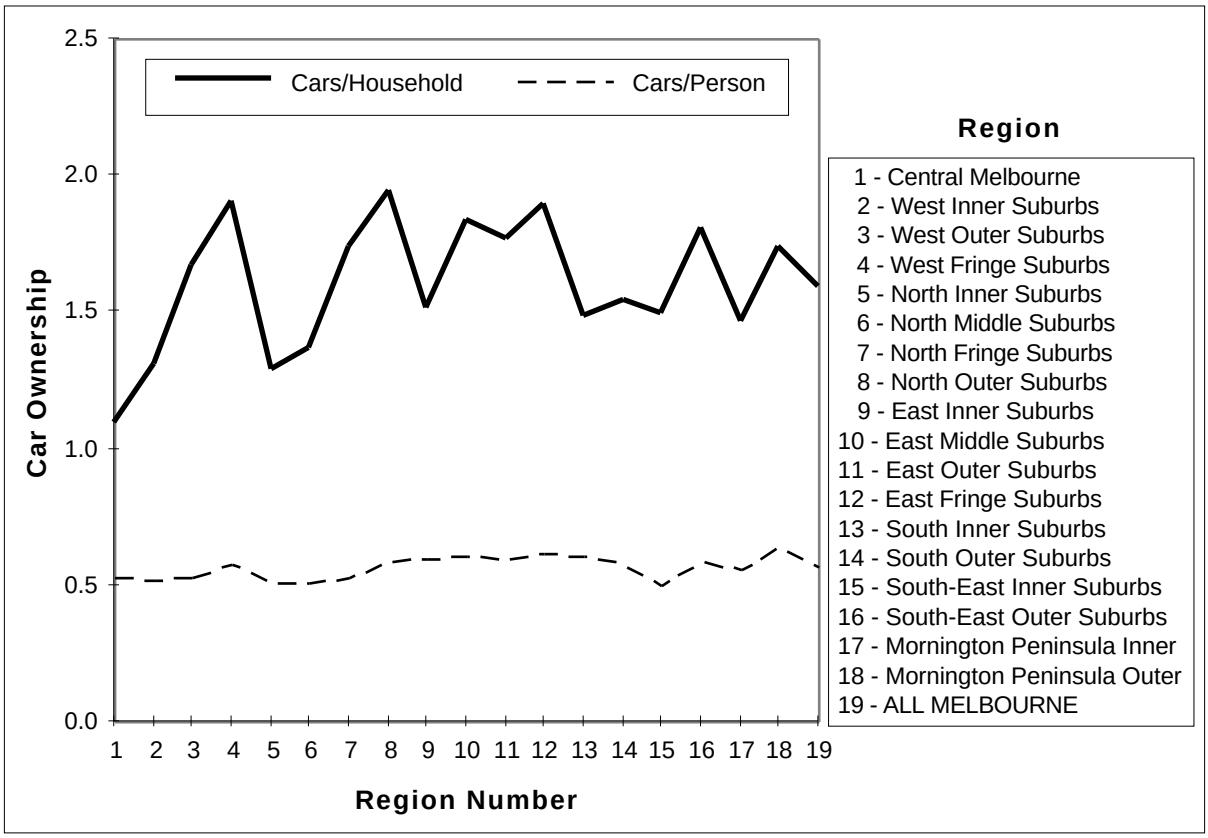

Figure 7 Car Ownership in Different Regions of Melbourne

This paper, therefore, examines some new definitions of car availability for home-based trips. It replaces the notion of total household car ownership with a measure of "cars at home" for any particular trip, on the grounds that it is only those cars currently at home that can be used for a trip starting from home at that time. The temporal variation in "cars at home" over a typical day might be as shown in Figure 8.

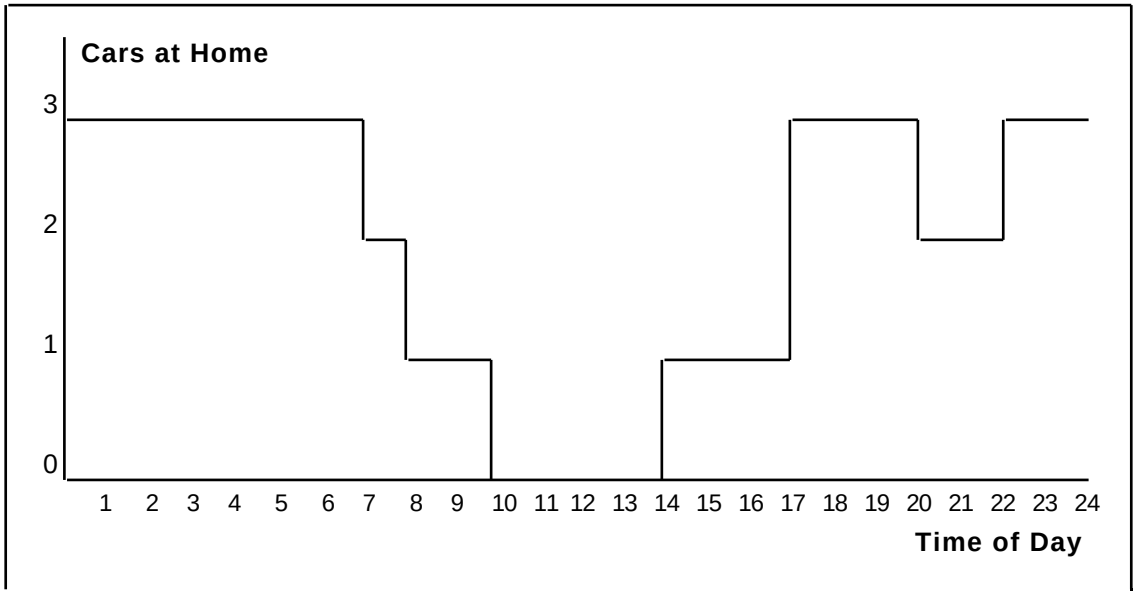

Figure 8 "Cars at home" during a Typical Day

This profile represents a typical household of five people which "owns" three cars, garaged at the residence overnight. At 7am, the husband leaves for work in one of the cars, driving by himself. At 8am, a daughter drives off to work, giving a lift to her teenage brother who she drops off at the railway station for his journey to high school. At 10am, the wife drives to the regional shopping centre, leaving her mother at home. At 12 noon, the mother walks a kilometre to the local shops to buy some milk and bread for lunch, returning at 1pm (this does not appear on Figure 8, because a car was not used for the trip). At 2pm, the wife returns from the regional shopping centre. At 4pm, the son arrives home from school, having walked from the railway station to home (this does not appear on Figure 8). At 5pm, the husband and the daughter both arrive home from work. At 8pm, the son drives his sister's car to a friend's house to work on an assignment, returning home at 10pm. In this example, the car ownership is 3, and the cars per person is 0.60.

Such a travel and activity profile would be recorded in the VATS survey as a sequence of trip legs and activities. From such data, it is possible to calculate the number of "cars at home" at any time of the day using the following procedure:

- estimate any missing times for the start and end of trip legs, using neighbouring trips to set reasonable bounds
- for each home-based trip leg in a household, record an "event time" as the start of a trip leg for an outgoing trip and the end of a trip leg for an incoming trip
- sort all the trip legs within a household in increasing order of "event time"
- where several trip legs in a household have equal "event times", place outgoing car driver trips at the end of this group, and incoming car driver trips at the start of this group

- within each household, work through the ordered list of trip legs, subtracting one from the "cars at home" for each outgoing car driver trip and adding one to the "cars at home" for each incoming car driver trip
- transfer this information from the trip leg file to the linked-trip file

The above procedure gives rise to a measure of the "supply" of cars at home during the day, as illustrated in Figure 8. However, during the day, the "demand" for these cars at home is also varying, depending on the number of "people at home" at any given time. The profile of "people at home" for the above example is shown in Figure 9.

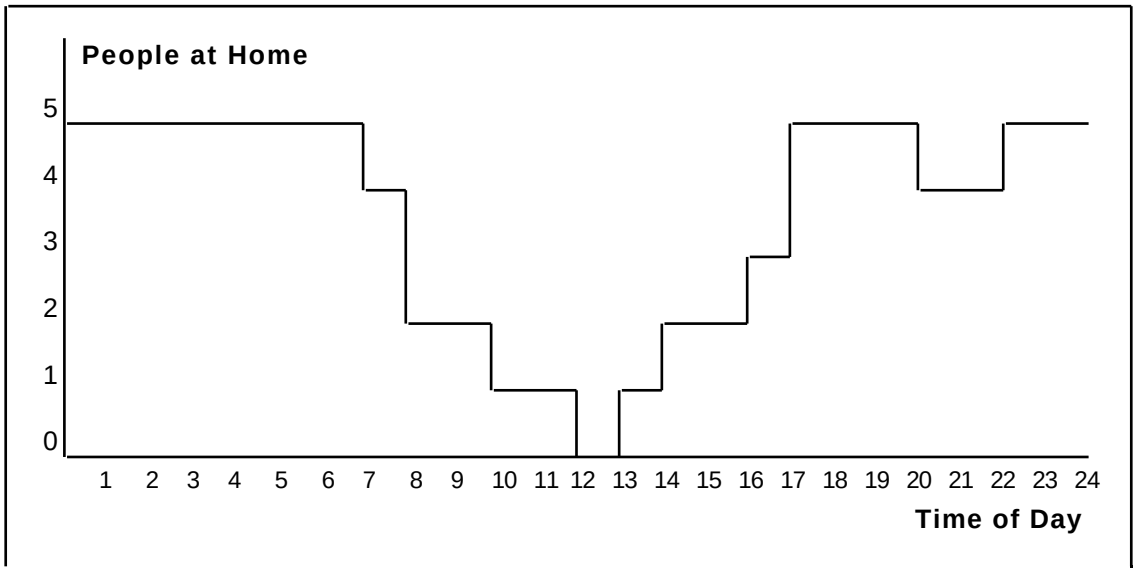

Figure 9 "People at home" during a Typical Day

Use of the information in Figures 8 and 9 gives rise to two different measures of "access to cars" which are, in many ways, temporally-varying equivalents of the household car ownership and cars/person measures used earlier in this paper. Thus, "cars at home" measures the supply of cars at home when a particular trip is made, while the ratio of "cars at home" to "people at home" is a measure of the supply/demand ratio, termed "car availability" hereinafter. The comparisons between these equivalent measures are shown in Figures 10 and 11, for actual data from the VATS survey. Figure 10 compares the distributions of household car ownership and the number of "cars at home". Both distributions are calculated from observations made at the time when people in the household make an outgoing trip of any type.

It can be seen that the average number of "cars at home" is, quite naturally, less than the car ownership at the times when trips are being made because not all cars are at home all the time. Note that the car ownership distribution in Figure 10 is quite different to that for Melbourne in Figure 1, because households with more cars are more likely to make trips and hence appear more frequently in the distributions in Figure 10. Therefore, Figure 10 represents Figure 1 convoluted by Figure 5. While trips are most likely to be made by households owning two cars, there is most likely only one of these cars at home when those trips are being made.

A very different picture presents itself, however, when comparing the cars/person measure with the car availability index of "cars at home"/"people at home", as shown in Figure 11. Whereas, the "cars at home" distribution was skewed to the left of the car ownership distribution in Figure 10, the distribution of the car availability index is skewed to the right of the cars/person measure, as shown in Figure 11, with the average car availability being higher than the average cars/person. This somewhat counter-intuitive result is easily explained in hindsight, since the decrease in "cars at home" is simply not as fast as the decrease in "people at home". Therefore,

even though a car trip takes a car out of the home, it also takes a driver, and sometimes passengers, out of the home as well. In addition, people also leave the home by means other than the car. Therefore, the competition for the car(s) left at home is decreased. Essentially, the demand for the car(s) decreases more than the supply of the car(s). Obviously, in some cases, such as a car leaving a household which originally contained two people and one car, the car availability will decrease after the car leaves. However, in a population with relatively high car availability such as Melbourne or Brisbane, the overall effect is for car availability to increase as cars (and people) are removed from the household.

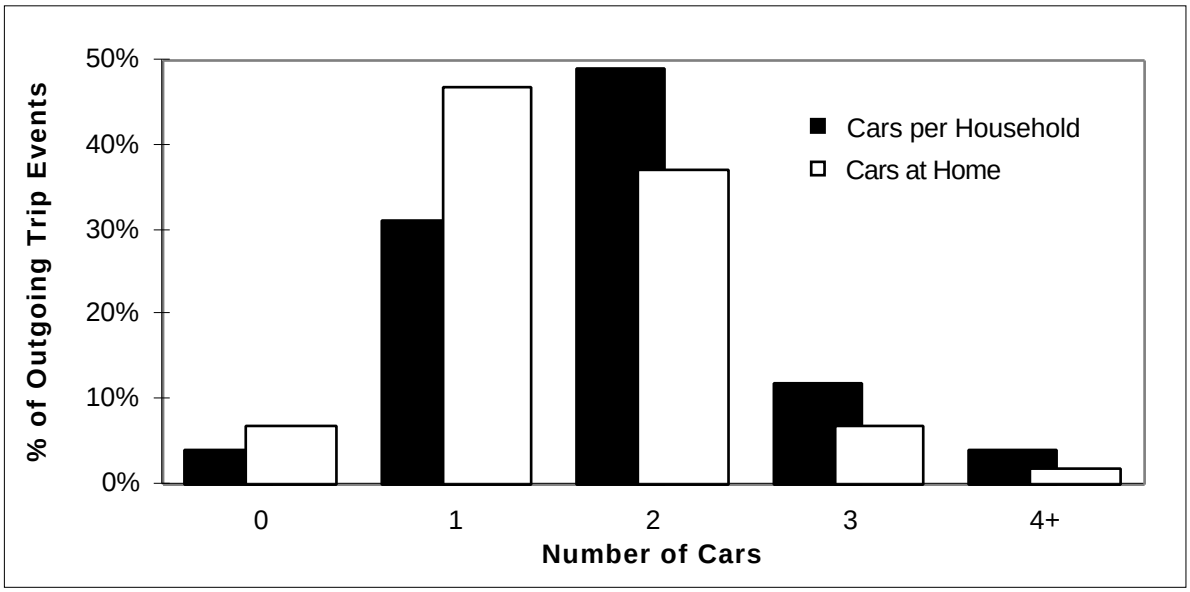

Figure 10 Distributions of Car Ownership and "Cars at Home"

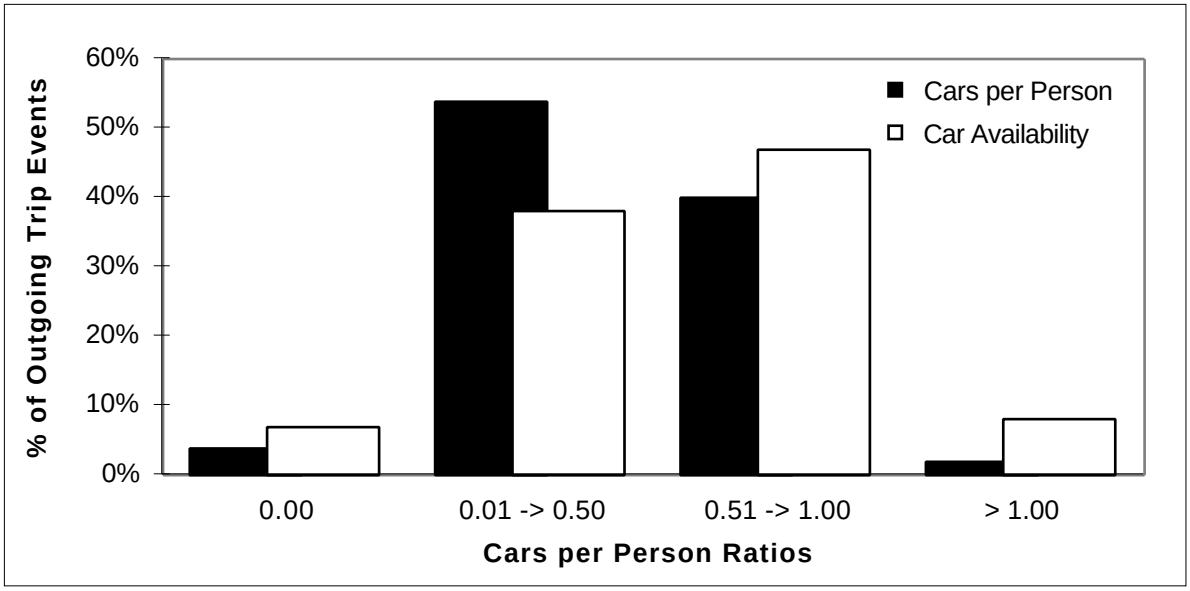

Figure 11 Distributions of Cars/Person and "Car Availability"

Given the overall decrease in "cars at home" shown in Figure 10 and the increase in car availability shown in Figure 11, the question remains as to whether these increases and decreases have occurred evenly across the population. Given the above explanation, one might expect that car availability might decrease, relative to cars/person, in areas where cars/person was already low. However, as seen in Figure 7, the cars/person measure is relatively constant across all Melbourne regions. One might not, therefore, expect much variation geographically, and this

is confirmed in Figure 12, where it is seen that the difference between cars/person and car availability is relatively uniform across all Melbourne regions (note once again, that the values for cars/person are higher in Figure 12 than in Figure 7, because Figure 12 is based on cars/persons values when outgoing trips are actually made).

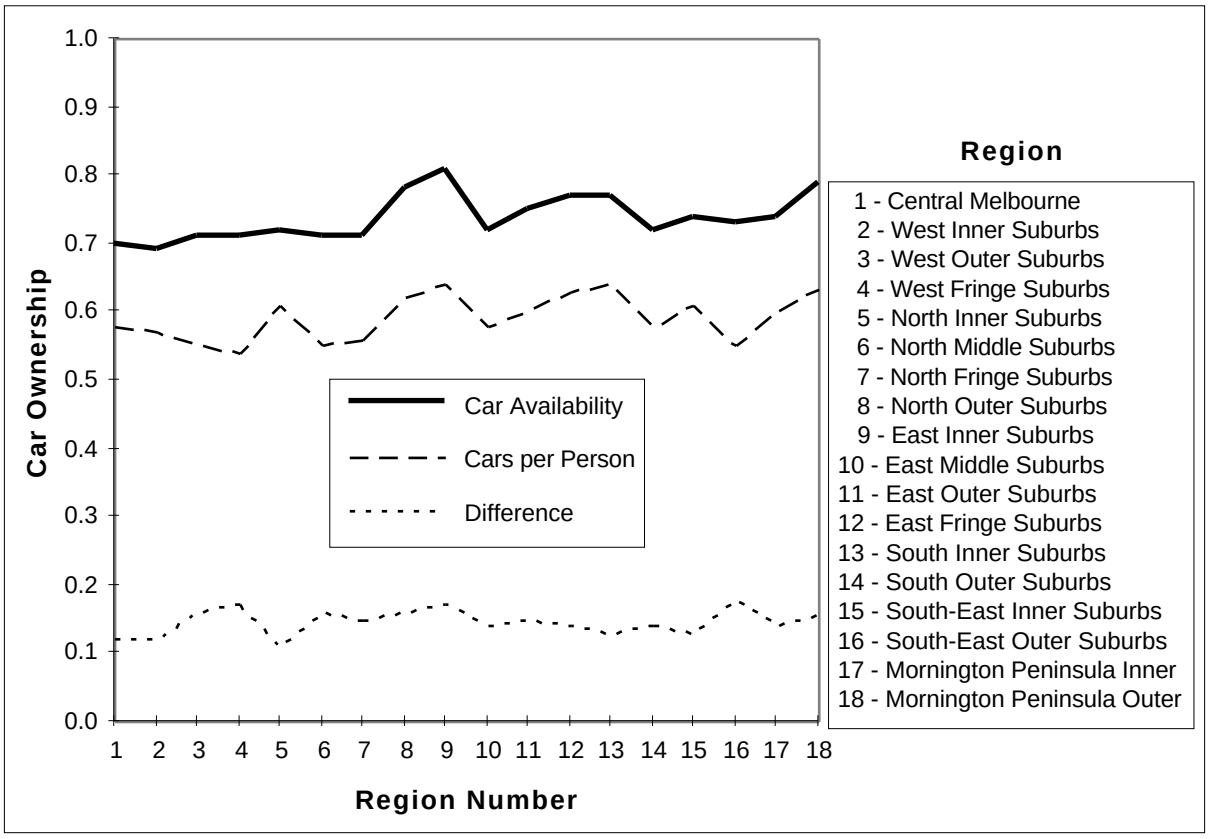

Figure 12 "Car Availability" across Melbourne Regions

It is clear from Figures 8 and 9 that significant variations in "cars at home" and "people at home" occur at specific times during the day. It might therefore be expected that variations in car availability will also occur during the day. Figure 13 shows the car ownership and the "cars at home" for trips commencing at different times during the day, while Figure 14 shows the same results for cars/person and car availability.

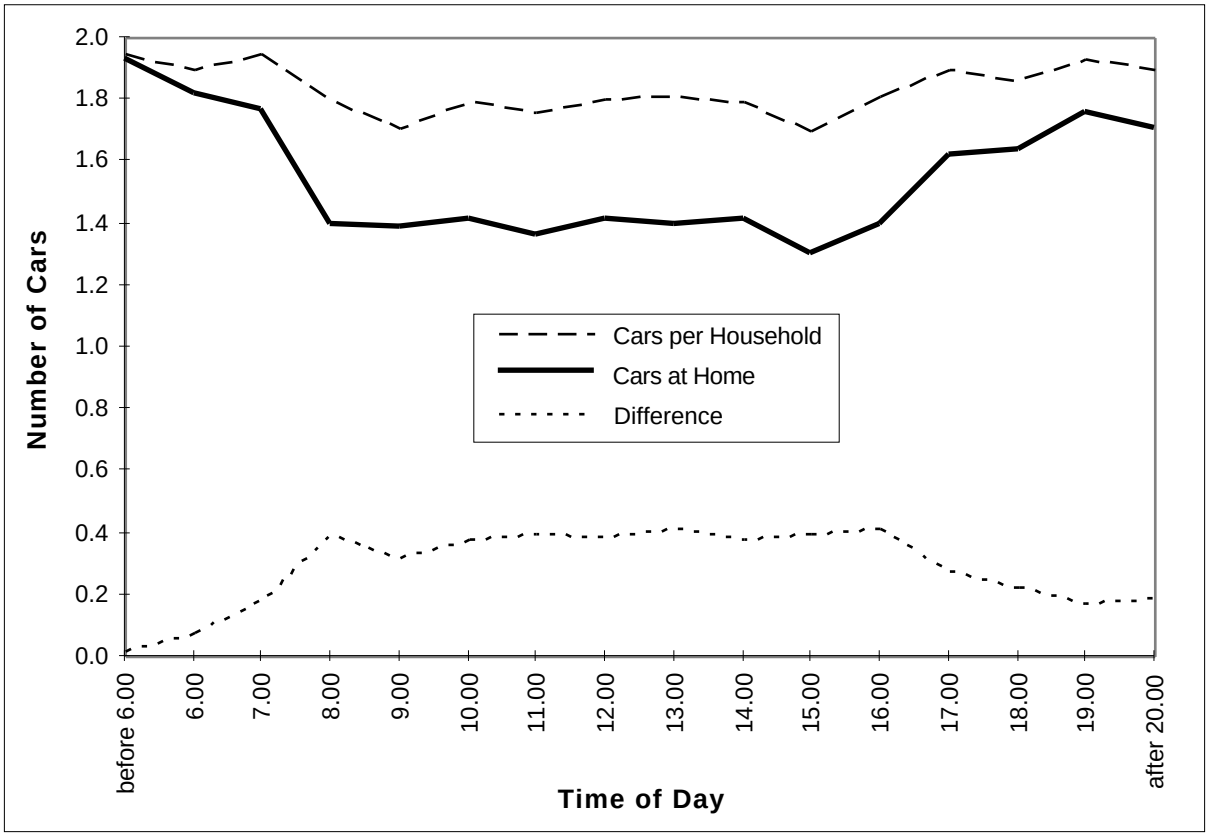

Figure 13 Car Ownership and "Cars at Home" during the Day

The "cars at home" drops from a value of nearly 2.0 early in the morning when all cars are at home to a low of about 1.40 during work hours from 8.00am till 4 p.m. On the other hand, the car availability index rises above the cars/person during that same period, as cars (and people) are away at work and school, leaving relatively little competition for any cars left at home.

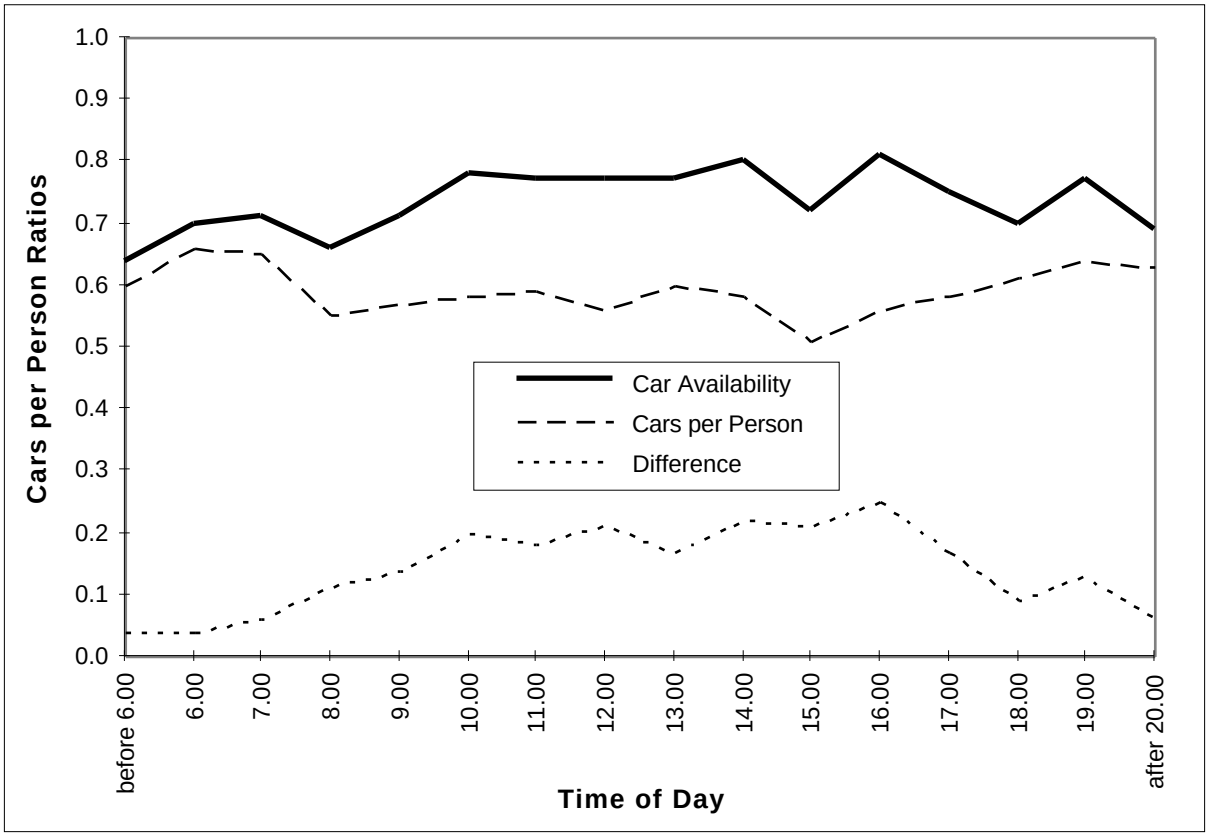

Figure 14 Cars/Person and "Car Availability" during the Day

Variations in the different measures of "access to cars" between the genders are shown in Figure 15 through 17. It can be seen in Figure 15 that there is no difference in household car ownership between male and female travellers. However, a significantly higher proportion of female travellers are faced with a smaller number of "cars at home" when they wish to make home-based trips, as shown in Figure 16. This is because females are more likely to be at home during the day, when the cars have been taken away from home by someone else in the household. However, because these trips by females are often being made during the middle of the day, when the females are alone at home with their cars, the competition for these cars is less and hence the car availability is higher for females than it is for males.

The above analysis has shown that females are more likely to be making trips from home when there are fewer cars at home, but also when there is less competition for those cars which are at home. Whether the competition between the genders for the car is played on a "level playing field" when both males and females are at home, however, is an interesting matter for further research.

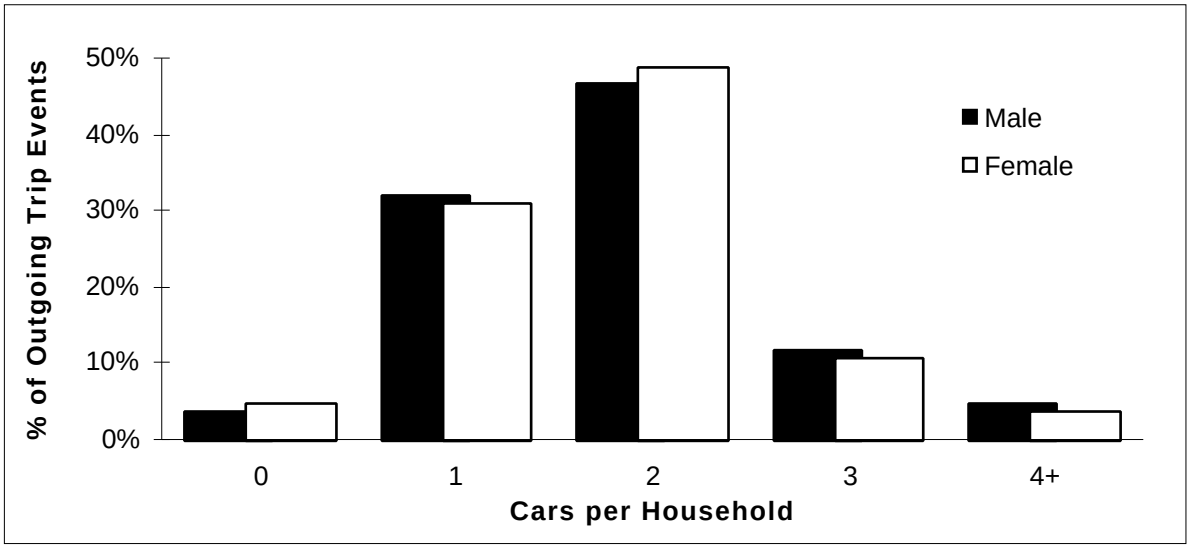

Figure 15 Household Car Ownership for Outgoing Trips by Gender

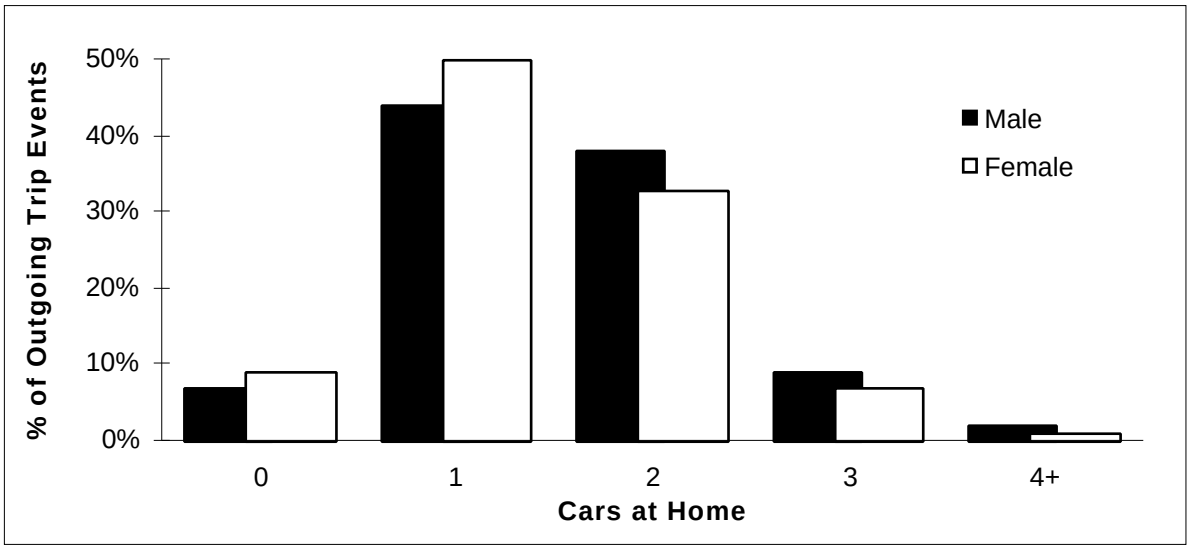

Figure 16 "Cars at Home" for Outgoing Trips by Gender

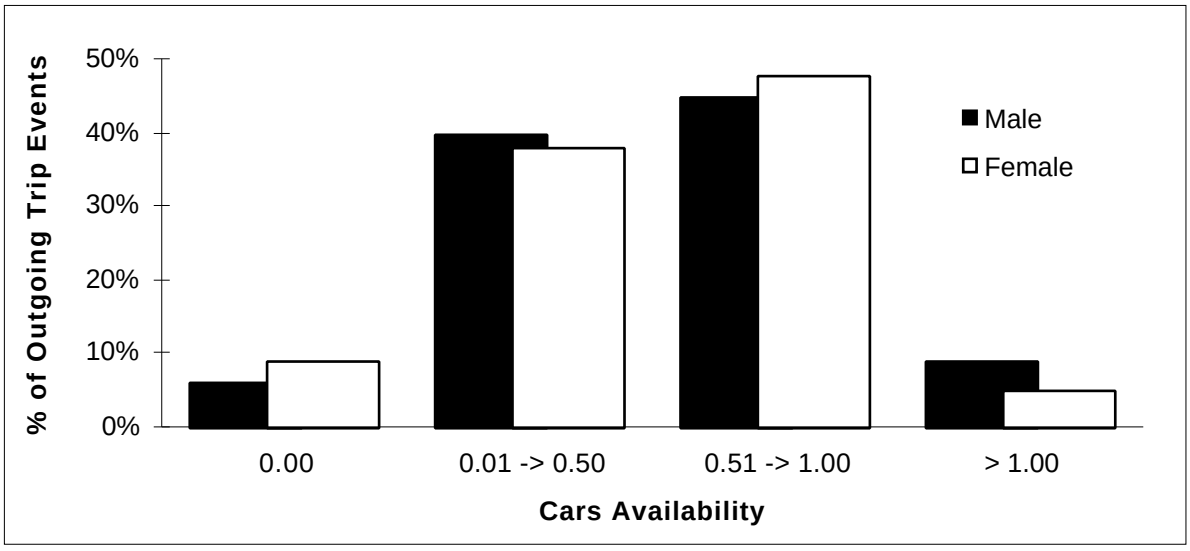

Figure 17 Car Availability for Outgoing Trips by Gender

5. CONCLUSION

This paper has looked at a number of measures of "access to cars", specifically for home-based trips, ranging from household car ownership, to cars/person, to "cars at home", to the ratio of "cars at home" to "people at home". It has been shown that these latter measures are calculable from travel survey data sets, provided that sufficient details are collected about all trips. The investigations reported in the paper have yielded some interesting conclusions:

- car ownership patterns are very similar in Melbourne (1994) and Brisbane (1992)
- 11% of all home-based cars, and nearly 50% of all new cars, are company cars
- household trip rates vary approximately linearly with household size and household car ownership
- car ownership is a major determinant of mode choice with 50% of trips in non-car-owning households being by non-motorised transport and 35% being by public transport
- cars/person is virtually constant across all regions of Brisbane and all regions of Melbourne
- car availability should be measured at the times when outgoing trips are being made, and not as an average across the day
- while "cars at home" decreases at home during the day, car availability actually increases because of the reduction in competition for the car(s) left at home
- while "cars at home" is lower for home-based trips made by females, car availability is higher for home-based trips made by females because of the reduction in competition for the car(s) left at home during the day.

Future research in this area should concentrate on deriving indices of car availability for all people (not just travellers) in a household, on extending the concept of car availability to account for non-home-based trips, and on examining in more detail the social dimension of car availability and its interaction with the demand for public transport.

REFERENCES

de Jong, G. (1997). "A Microeconomic Model of the Joint Decision on Car Ownership and Car Use". In P.R. Stopher and M.G. Lee-Gosselin (Eds.), *Understanding Travel Behaviour in An Era of Change*, Pergamon: Kidlington, U.K.

Hensher, D.A. (1986). "Dimensions of Automobile Demand: An Overview of an Australian Research Project", *Environment and Planning A*, 18, 1339-1374.

Luk, J. and Richardson, A.J. (1997).*Company Cars and the Management of Travel Demand.* Research Report ARR301, ARRB Transport Research, Melbourne, Australia.

Richardson, A.J. and Ampt, E.S. (1993a). *1992 South-East Queensland Household Travel Surveys: Final Report 1- Brisbane.* TRC Working Paper 93/3, Transport Research Centre, The University of Melbourne.

Richardson, A.J. and Ampt, E.S. (1993b). *The Victorian Integrated Travel, Activities and Land-Use toolkit (VITAL).* VITAL Working Paper 93/1, Transport Research Centre, The University of Melbourne.

Sansom, T. and Dawe, G. (1996). "Developing Car Ownership and Use Models from Disaggregate Data", *24th European Transport Forum*, Seminar D&E, London.