What role does car parking restraint play in mode choice for commuter travel to Sydney's CBD?

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1 Introduction

Conventional wisdom identifies restricted availability of car parking in the Sydney CBD as the main determinant of high public transport use. This paper explores the relationship between commuter mode choice to the Sydney CBD and car parking availability and the relative attractiveness of non-car modes for this particular travel. A description of transport and land use characteristics of the CBD is provided, in order to orient the reader and provide an indication of the scale and nature of the commuter transport task. Preliminary analyses are summarised that seek to find a simple relationship to explain commuter mode choice to the CBD. A relative accessibility analysis of the CBD for different modes is used to examine and try to explain the market structure evident in the journey to work data.

2 Transport characteristics of Sydney's CBD

Parking restraint is used here to describe a situation where there is insufficient parking to meet potential demand and/or available parking has a relatively high cost in terms of user charges. The Sydney CBD has been subject to restrictive parking provisions for many years, with the current level of parking permitted in new commercial buildings based on the built form's footprint area at 1 space per 50 square metres, yielding a parking provision that depends upon the ratio of floorspace to built form footprint. This could result in parking provision of between 1 space per 150 square metres of gross floor area to 1 space per 500 square metres of gross floor area.

In addition to restricted parking provision, a number of new public car parks have had restrictions placed on their opening hours (e.g., World Square), typically involving a morning peak period curfew, where the facility may not open to the public prior to a specified time. Further, parking charges within the CBD are relatively high, with casual parking in a public car park ranging from around $5.00 to $15.00 per hour during the week; although permanent spaces can be arranged for a lower per hour charge. The perceived cost of parking by employees would obviously depend upon whether they are provided with a space as part of their remuneration package or if they must pay for it themselves.

In addition to restricted parking supply and relatively high parking charges, the state government applies a parking space levy (PSL) (Ministry of Transport, 2006) to parking spaces within the CBD (it also applies in a number of other centres). The Parking Space Levy Act (1992 no 32, as amended) defines this tax on parking spaces, and how the revenue is to be used. Unusually for an Australian tax, the revenue raised by the PSL is hypothecated, in this case to the Public Transport Infrastructure Fund, which has been spent on a number of transport initiatives, including commuter car parking at some suburban railway stations, as well as on public transport facilities. The tax rate for a space in category one areas was increased on 1 July 2006 to $900 per annum (Office of State Revenue, 2006). The CBD (City of Sydney Council area in 2001) is designated as a category one area. Despite a review of the PSL in 2003/4 by the State Government, there is a lack of information about the effect of this tax on transport outcomes or on its efficacy in meeting its legislative objects.

Sydney's CBD does not have a precise geographic definition. It is generally accepted as the area covered by the old City of Sydney council boundaries, prior to the merger with South Sydney in 2003. While it is not the role of this paper to identify precisely the boundary of the

CBD, a number of transport performance indicators suggest that the CBD is a subset of this widely accepted definition. For the purposes of this paper the old Sydney LGA is considered to be the CBD, with two Transport and Population Data Centre travel zones (TZ48 – Garden Island dockyard and TZ838 – Hyde Park with 47 employees) removed from the detailed analysis.

Sydney's CBD is characterised by employment of approximately 260,000 (City of Sydney, 2003) and a population of 47,200 (ABS, 2003). In 2001, it had around 60,500 car spaces, of which 26,100 were public spaces, 26,000 were business spaces and 8,400 were resident parking spaces (City of Sydney, 2003) – as the broadest possible measure of off-street parking availability for commuters, there were 4.3 workers per space. It should be noted that on-street parking is not included in these figures – although the availability of all day on-street parking is heavily restricted.

An extensive rail network feeds to, and through, and around the CBD, covering a broad swathe of Sydney's suburbs; rail lines serve seven stations within the CBD. During the morning peak hour of 8am to 9am there are approximately 74,000 exits from the CBD stations (CityRail, 2003). The government bus system is focussed on the CBD, along with buses run by a number of private operators. During the morning peak in 2001 there were approximately 1,100 state buses entering the CBD between 7am and 9am (City of Sydney, 2004). A ferry network is based on Circular Quay at the northern end of the CBD, connecting with a number of harbour side suburbs. A recent addition is the light rail line through Pyrmont to Central Station.

Of the workers who travelled on Census day, the journey to work mode shares were 48.4% train, 19.0% bus, 18.7% car driver, 3.9% car passenger and 10.0% other. These proportions are taken from journey to work table 2 where trips are coded to a hierarchy of modes (ABS, 2003A). Consequently, commuters using bus or car to access train stations are not identified separately. Other data limitations include non-identification of broken journeys on the way to work and there is no time of day variable in the data. For the purposes of this paper, it is assumed that commuters travel to work in the morning peak and they do not break their journey. Obviously these assumptions will lead to unexplained variability in relationships between cost and mode choice variables.

3 Exploration of mode choice

A number of simple relationships were explored to see if there was a quick and straightforward way to explain mode share for commuter travel to the CBD. Firstly, the variability in mode share among CBD zones was plotted (Figure 1).

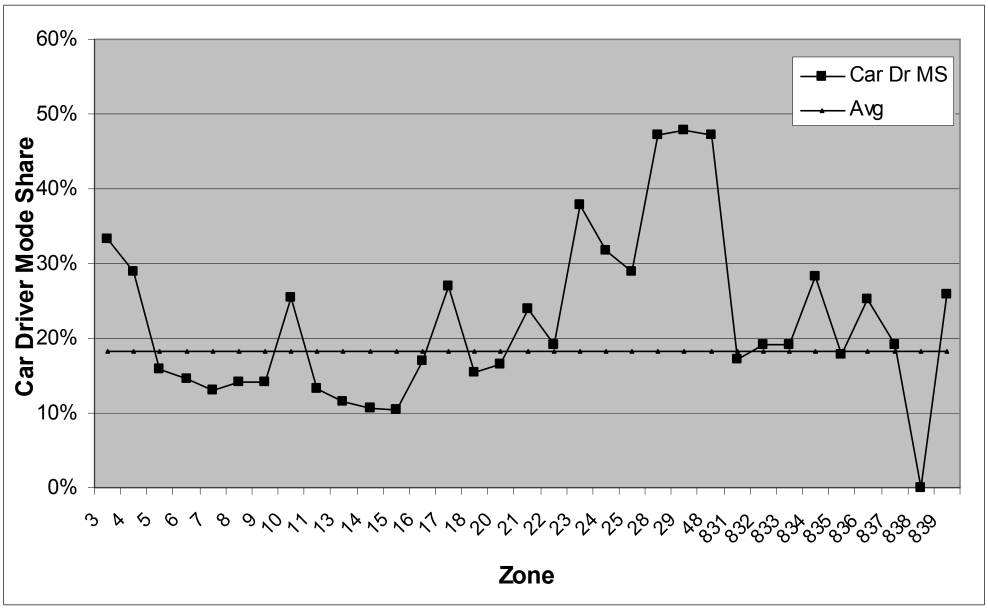

Figure 1 Car driver mode share by travel zone

This chart shows nine zones with very similar low car driver mode shares of between 16% and 10%. These zones are 5, 6, 7, 8, 9, 11, 13, 14 and 15. There is, however, a fairly substantial variation in car driver mode shares between zones, which was expected to provide fertile ground to test the relationship between car driver mode share and parking availability.

The following two charts plot employees per car space total (Figure 2) and per tenanted car space (Figure 3), two separate measures of parking restraint, against car driver mode share. Mode share data is from ABS (2003a) and the car parking availability data is from City of Sydney (2003). Both charts exclude zone 838, which has no car parking and only 47 jobs. The second chart also excludes zone 13 which had 71 employees per parking space and 11% car driver mode share.

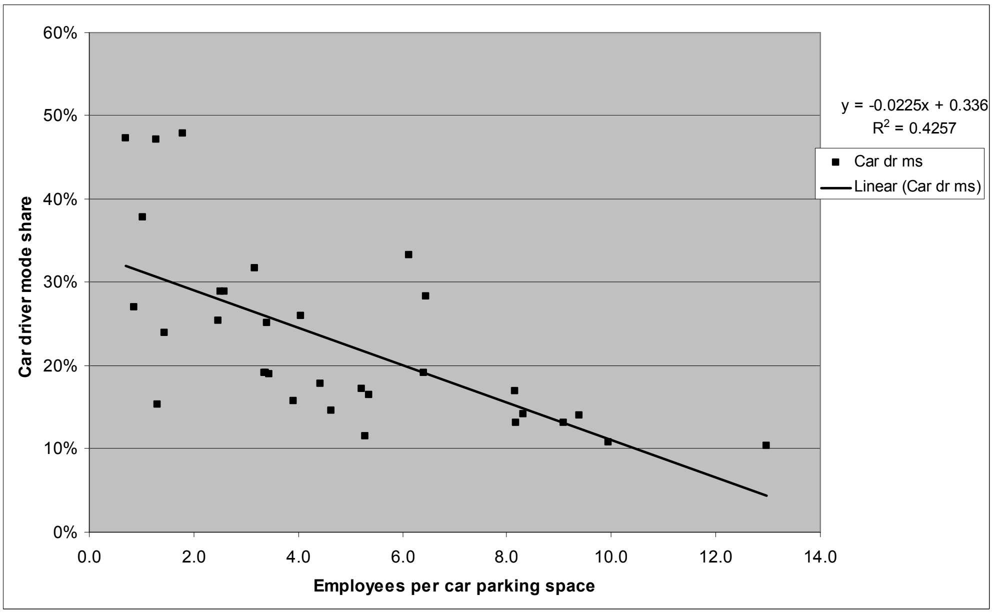

Figure 2 Employees per total parking spaces versus car driver mode share

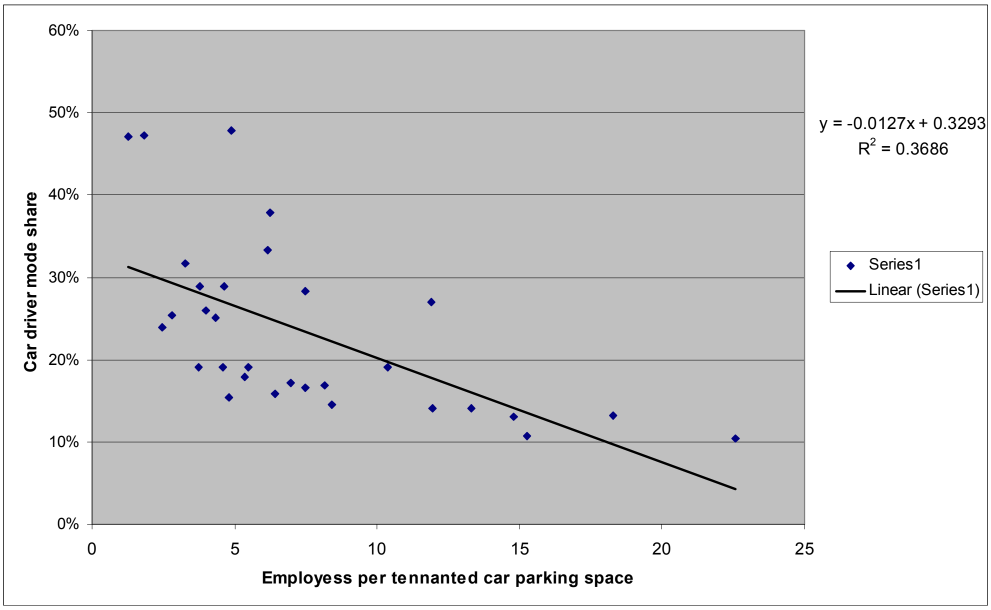

Figure 3 Employees per tenanted parking space versus car driver mode share

These charts suggest that as these indicators of parking restraint increase, car driver mode share falls, supporting the view that parking restraint is important. However, the goodness of fit is poor for both relationships, with parking restraint explaining less than half the variability in car driver mode share. One possible reason for this scatter might be that some commuters park their cars outside the zone in which they work, and then walk to their workplace.

A further feature of the charts is the degree of parking restraint when considering tenanted parking, with many zones having more than five employees per parking space and eight zones having more than ten employees per parking space.

To gauge the likely importance of public transport accessibility in explaining mode choice, the walk distance from each zone to the nearest CBD rail station was measured. This variable is plotted against car driver mode share in Figure 4 below.

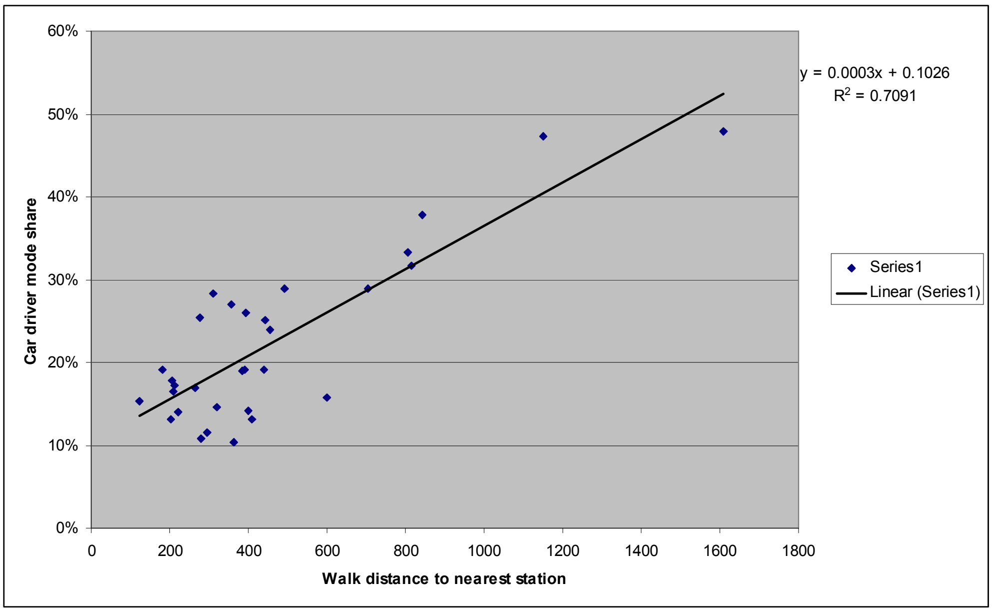

Figure 4 Walk distance to nearest rail station versus car driver mode share

The goodness of fit for this linear correlation is good, with variation in distance to the nearest rail station explaining just over two-thirds of the variability in car driver mode share. A possible reason for this is correlation might be that car parking becomes relatively scarce close to rail stations, rather than the transport accessibility provided by the rail station. A further plot was prepared to test to what extent this might explain differences in mode choice and is shown in Figure 5.

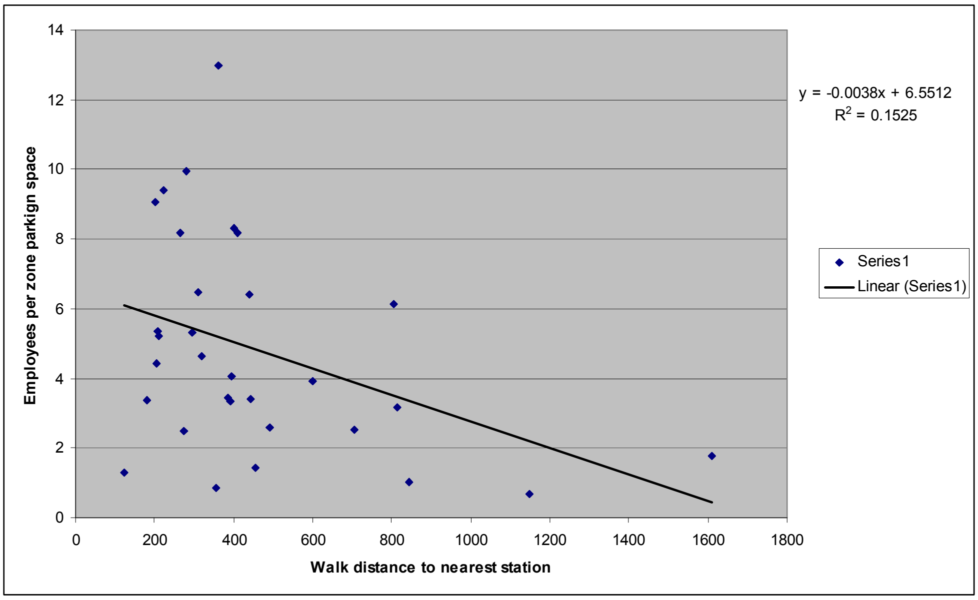

Figure 5 Walk distance to nearest rail station versus employees per zone parking space

The chart does indicate that car parking becomes relatively scarce as the distance to the closest station decreases. However, the very high degree of scatter indicates that other factors are involved.

Over the past fifteen years there has been a substantial increase in resident population within and in close proximity to the CBD. A number of commercial buildings have been converted to apartments and new apartments have been built. The Pyrmont peninsula has seen a particularly rapid transformation from brownfield industrial land to mixed use, including residential. It is a walk of between 800 metres and 1,500 metres to the core of the CBD across Pyrmont Bridge, and other mode share for commuters in these sub-markets is high. For commuter travel between Pyrmont (travel zone 29) and eleven core CBD zones, other mode share ranges between 40% and 75%, with a frequency-weighted average of 68%.

3.1 Summary

From the above exploration of the transport characteristics of the CBD there is:

- A poor correlation between car parking availability and car driver mode share
- A good correlation between walk distance to a zone's nearest train station and car driver mode share, and this does not seem to be explained by relative availability of car parking close to stations
- Mode share for commuter travel to the CBD from travel zones within or close to the CBD is heavily weighted to other mode

4 Accessibility analysis

4.1 Description

The objective of the accessibility analysis was to compare estimates of perceived travel time to the CBD by different modes in order to see if this might explain mode choice. Firstly, comparing perceived travel times might identify sub-markets, if any, that enjoy a transit travel time advantage over car travel time to the CBD. If differences in car travel time advantage over transit travel time correlates well with car mode share, then it would suggest that car parking restraint may play only a small role in mode choice for CBD commuters.

In order to conduct this analysis, a database of travel times was prepared for car and transit (rail and bus modes are called transit) access to the CBD from almost all travel zones on the Cumberland Plain (excluding the CBD and some largely uninhabited zones).

Weights were applied to various components of the journey time to better reflect perceived travel times from door to door.

Demand data, by mode, was taken from Table 2 of the journey to work dataset (ABS, 2003a). This provides detailed commuter travel information for origin zone by destination zone by mode, permitting the examination of over twenty thousand individual CBD access commuter sub-markets.

Appendix A explains the data used in the preparation of the perceived travel time and demand databases.

Long distance commuter markets from Wollongong, Southern Highlands, Blue Mountains and Central Coast were excluded from the analysis. These commuter markets to the CBD are dominated by train travel, and their travel to the CBD would not necessarily reflect travel behaviour from locations on the Cumberland Plain to the CBD.

4.2 Relative perceived travel times

The following chart shows the frequency distribution of zone pairs for which car and transit travel times were prepared by the relative perceived travel time advantage of car or transit.

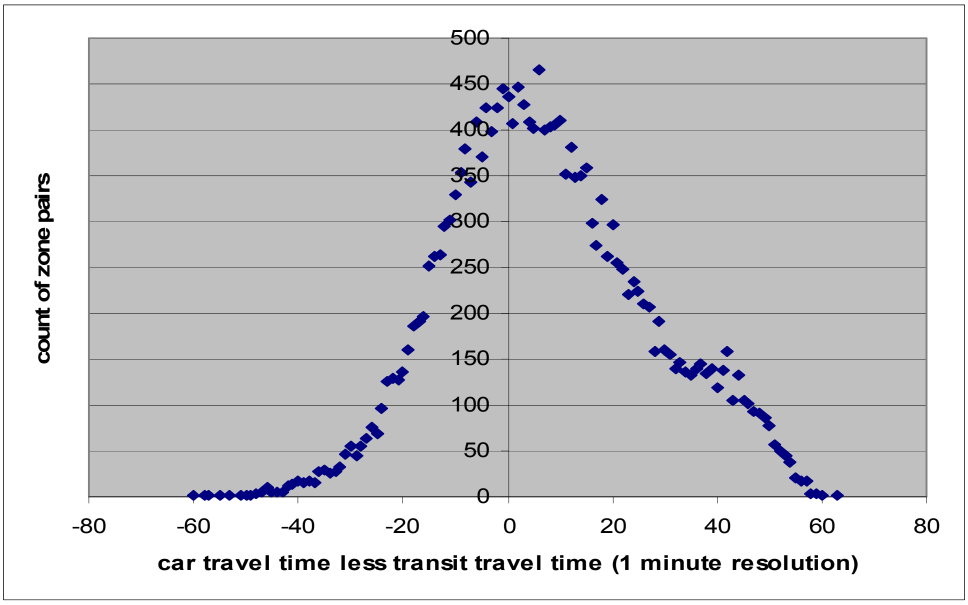

Figure 6 Frequency count of zone pairs by car travel time less transit travel time

This indicates that a substantial proportion of zone pairs have competitive transit travel times, i.e., the perceived travel time by transit is less than the perceived travel time by car (zones where car travel time less transit travel time is positive). The following chart shows the cumulative frequency distribution of car travel time less transit travel time.

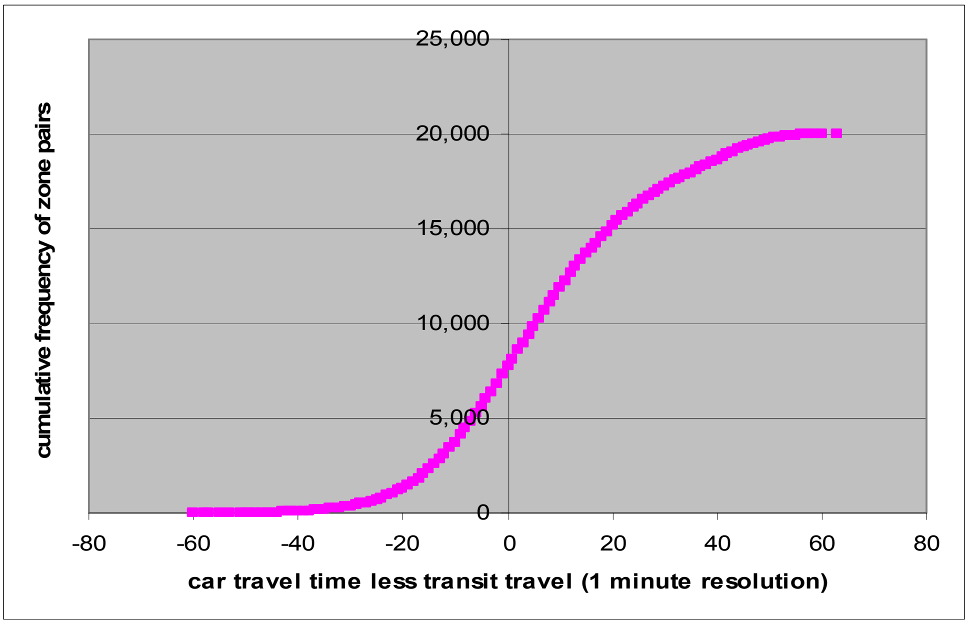

Figure 7 Cumulative frequency distribution of zone pairs by car travel time less transit travel time

The above chart shows that more than half of the zone pairs (i.e., 61%) have transit travel times that are less than car travel times. This level of transit travel time advantage was not an expected outcome of the analysis.

The chart below plots the cumulative number of trips by mechanised modes (i.e., train, bus and car) at different levels of car and transit travel time difference.

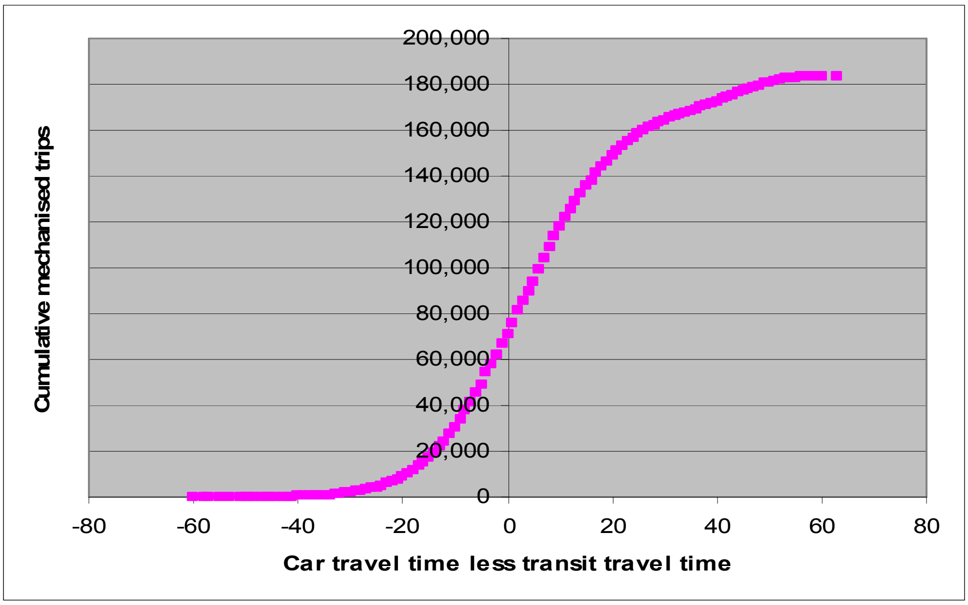

Figure 8 Cumulative frequency of mechanised trips versus car travel time less transit travel time

There were about 61% per cent of trips for which transit was more attractive than car. This compares with a journey to work mode share to transit of mechanised trips of 76.5% for the journey to work trips in the demand database (i.e., fitting the geographic scope of the analysis and for which travel times were available).

This analysis suggests that if mode choice were on the basis of relative perceived travel time alone, then the car mode choice would be around 40% versus the actual level of 23.5%. However, it should be noted that the journey to work dataset covers travel by commuters across the whole day, including at times that are out of the peaks, when car travel would be faster due to less congestion and public transport travel less attractive as availability of service reduces. The data also includes people who do not have a car available.

Further analysis of the proportion of travel demand by mode by car travel time advantage was undertaken to identify if there were differences between modes. The chart below shows the cumulative frequency of demand for each mode plotted against the travel time advantage to car.

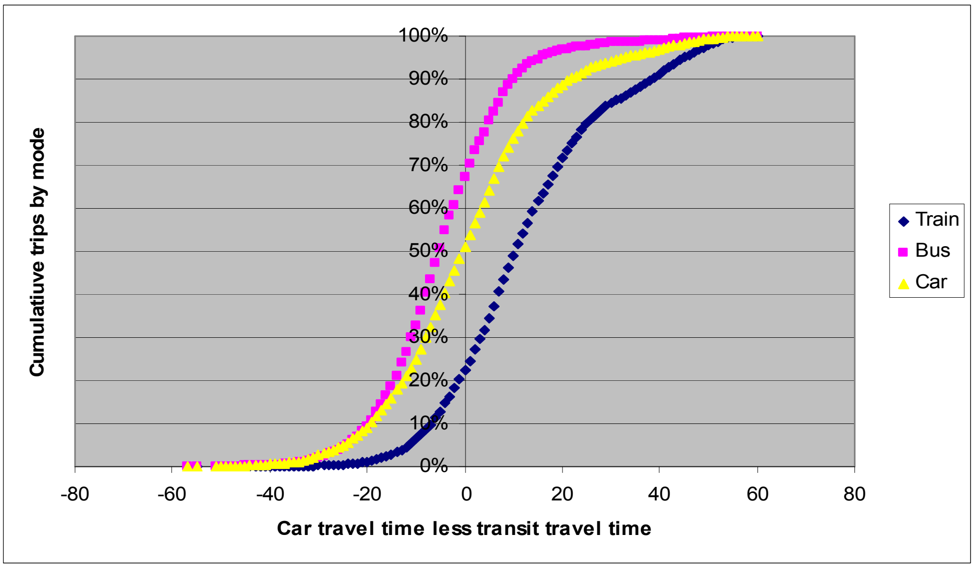

Figure 9 Car travel time less transit travel time versus cumulative trips by mode

Eighty per cent of train's demand to the CBD is from sub-markets for which car travel's perceived door to door times are slower than train travel's perceived door to door times. Simplistically, this suggests that about 20% of train users would be better off driving, if they had a car available and had access to a parking space.

Just over half car users would experience faster journeys by transit than car. This suggests that these commuters have some impediments that prevent them from using transit, such as:

- Need for a car during the course of their business, e.g., for tools or for visiting,
- Need a car because at their time of travel transit is relatively less attractive than car,
- Their commute journey involves a more complex pattern of travel than home to work.

About two-thirds of bus commuters would get to work faster if they drove. However, as with train, a proportion of these commuters would not have a car available for the commute. It should also be noted that the cumulative frequency curve for bus in the above chart is steeper than that for other modes, indicating that small changes in perceived travel time differences would shift a large proportion of bus users back to the right hand part of the chart, i.e., where transit is the faster mode. An eight minute difference in the relative travel time of car and bus would shift 17 percentage points of bus demand into the faster by transit category.

An issue with the travel time estimates developed for this study is deriving representative access costs for travel zones. This is especially the case for bus, where access and egress conditions are considered to be a major determinant of mode choice. Bus mode share is not homogenous within individual travel zones but varies with distance to bus routes. Consequently small geographic pockets of commuter demand within travel zones may face substantially lower bus travel access times than indicated by the travel times used in this paper.

This analysis indicates that transit is competitive with car for CBD commuter access for about 64% of mechanised commuter demand. About 12% of demand uses car when it would be faster to travel by transit. About 25% of demand uses transit when car would be faster. Recognising that some of the bus travel time estimates may overstate bus travel times and that a proportion of these transit users would not have access to a car, it suggests that for the commuter markets analysed in this paper, car parking restraint may only be having an influence on around 15% to 20% of the commuter market.

4.3 Mode choice and travel time differences

Disaggregate mode choice analysis of zone to zone pairs was not satisfactory, as a large number of zone pairs had few trips, which, when disaggregated by mode, resulted in many zero cells or cells with a value of 3, which might be a randomised trip frequency reflecting an actual trip frequency of 1 or 2. This is due to the manner in which the data is processed (a discussion of the processing is in Transport Data Centre, 2003). The chart below shows the result of the analysis.

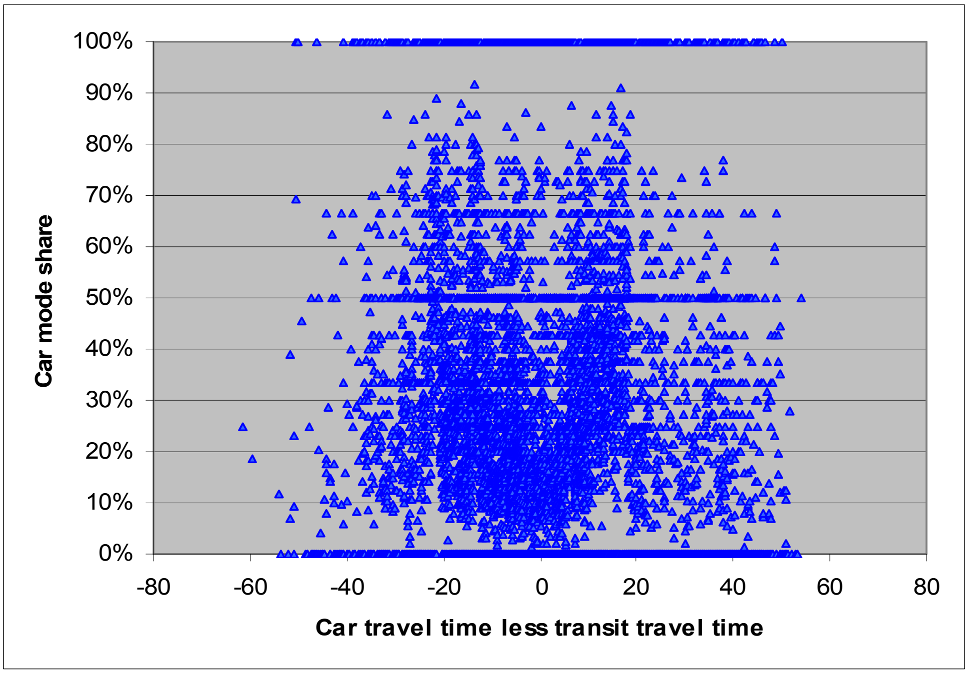

Figure 10 Car travel time less transit travel time versus car mode share

Consequently, demand data was aggregated based on differences in perceived travel time between car and transit to permit examination of variations in car mode choice with changes in relative travel times. A scatterplot of this data, at one minute resolution of car travel time less transit travel time, is shown in the chart below.

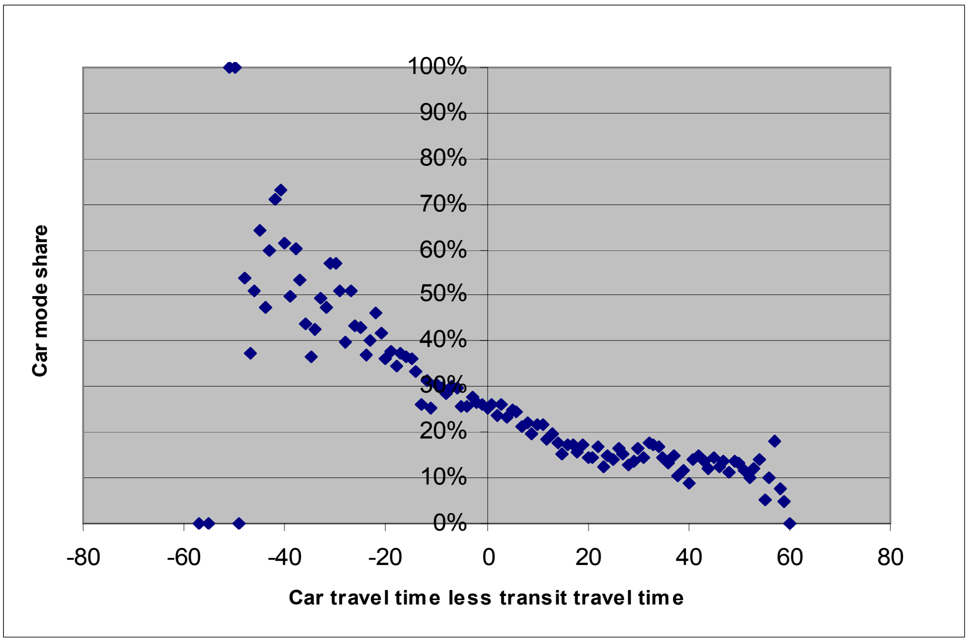

Figure 11 Car travel time less transit travel time versus car mode share

From a car travel time advantage of about 20 minutes (-20 on the chart's x-axis) through to a car travel time disadvantage of about 40 minutes (40 on the chart's x-axis) there is an obvious trend that suggests that car mode share correlates with difference in car and transit travel times. The increased volatility of car mode share to the left, at higher levels of car travel time advantage suggests that something else is affecting mode choice: at around 40 minutes longer to get to the CBD by transit than by car the car mode choice ranges between about 35% and 70%. However, part of the variability is due to uneven market sizes in successive minutes of travel time difference at either end of the plot. Consequently, the plot was reproduced using two-minute resolution of perceived travel time difference in order to reduce variations due to small market sizes at the extremes of the plot.

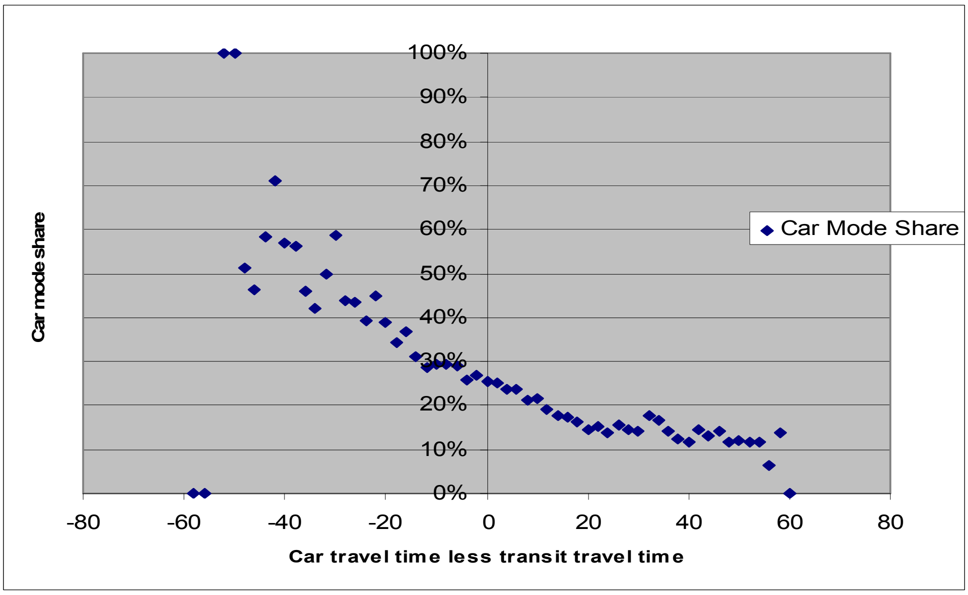

Figure 12 Car travel time less transit travel time versus car mode share

Aggregating travel time differences to two-minute intervals does dampen the scatter across the whole spectrum of travel time difference. Again, there is variability in mode shares at the tails of the plot, which is largely associated with small cell sizes (less than 40 mechanised trips per time difference interval).

A further refinement was to exclude cells at either end of the plot with less than 40 trips per two-minute travel time difference interval. This excluded one cell (a total of 12 trips) at the right hand end of the plot and four cells (a total of 12 trips) at the left hand end of the plot. The resulting plot is below with x-values shifted by 60 minutes to permit the fitting of an exponential curve for presentation purposes. A linear curve is also fitted to the data.

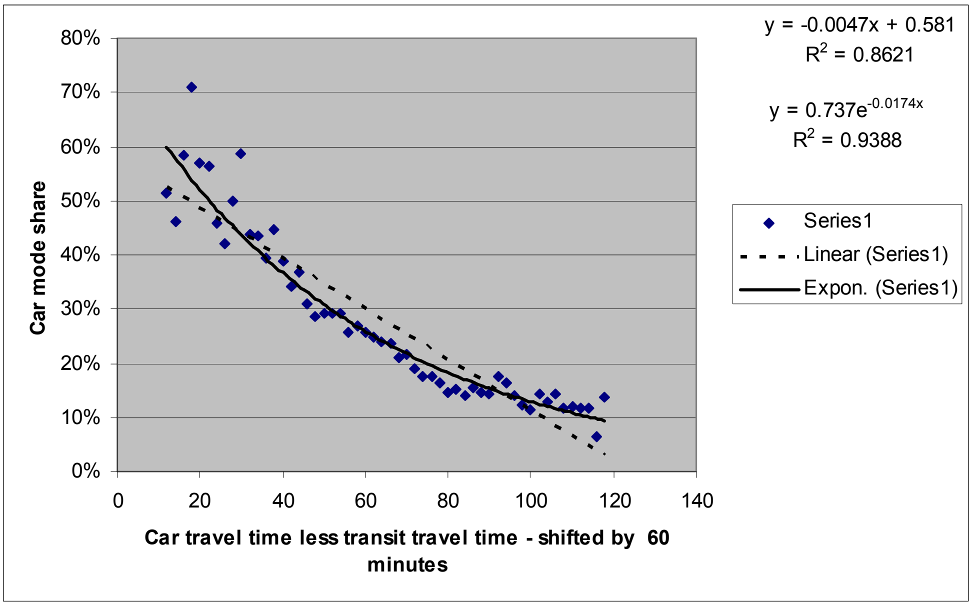

Figure 13 Car travel time less transit travel time versus car mode share of mechanised trips (x-axis shift 60-minutes to right)

This scatter plot shows a strong negative correlation when an exponential curve is fitted. It suggests that about 94% of the variability in car driver mode share is explained in terms of variations in the differences in travel time between car and transit. Other factors, such as car parking availability, availability of car and availability of transit at the time of travel, are likely to explain the rest of the variability. The functional form is:

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Car mode share = 0.737 * e(-0.0174*(travel time difference +60))
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The linear curve has a poorer fit to the data, but still indicates about 86% of the variability in car mode share is explained by variations in travel time difference between car and transit.

5 Discussion

The analysis indicates that it is the attractiveness of different modes' perceived travel times that correlates strongly with car mode choice. Initial analysis shows a good correlation between walk distance to nearest train station and car mode share. The accessibility analysis shows that perceived transit travel times are competitive with car for a large proportion of individual zone pairs (61%). When weighted by demand, about 61% of the commuter market analysed in this paper faced transit travel times that were more competitive than car travel times.

The analysis identified that about 12% of commuter demand used car, when car had travel times that were slower than perceived transit travel times. These commuters are likely to either require a vehicle in the course of their work, or travel at a time of day when transit does not offer a competitive travel time. It had not been expected that such a large proportion of commuter demand would be 'forced' to use car to the CBD.

Examination of travel time difference between car and transit, at two minute aggregations, indicated a strong negative correlation with car mode choice. With an exponential curve, about 94% of variability in car mode share was explained by variations in travel time differences between car and transit. This suggests that a small proportion of variation would be explained by other factors, such as car availability and car parking availability.

Conventional wisdom that the CBD's high mode share to public transport is due to car parking restrictions clearly needs to be questioned. Consequently, using it as a basis to support the introduction of restricted parking policies in other locations within Sydney, in the absence of high levels of transit accessibility, is unlikely to result in substantial reductions in car mode share for commuters at those locations. It may simply increase access costs to a level that makes use of those centres, beyond a particular level of development, unattractive. Achieving CBD-levels of relative transit accessibility elsewhere in Sydney would be a major challenge for relevant agencies and stakeholders.

That about 12% of commuters were using car when transit offered a faster travel time suggests that, even in a centre with high levels of transit accessibility, car parking provision is necessary for workers who require a vehicle in the course of their work, or who make either the inbound, outbound or both commute trips when transit is either unavailable or highly unattractive.

6 Conclusions

The Sydney CBD is an area of concentrated land use activity, with high levels of transit provision and use. It has restricted car parking availability, with parking in new developments even more heavily restricted. Available parking is subject to high charges and a State Government tax, the Parking Space Levy, of $900 per space per annum.

Variability in car driver mode share was found to be correlated well with variations in walking distances to the nearest train station in the CBD. Variability in car driver mode share was found to be poorly correlated to relative parking availability.

An accessibility analysis identified that a high proportion of zone pairs analysed showed that estimated perceived transit travel times were faster than perceived car travel times. Around 61% of zone pairs analysed had a transit travel time advantage, whilst about 61% of the travel demand analysed had a transit travel time advantage.

Analysis of car mode shares by perceived travel time difference had a strong correlation, suggesting that about 94% of the variation in car mode share is explained by variation in travel time difference. The remaining variability would be explained in terms of other factors, such as car parking availability and car availability, as well as time of day of travel.

The analysis in this paper indicates that the apparent role of car parking restraint policies in the CBD in achieving low car use for the journey to work ought to be placed in an appropriate context. That is, a large proportion of commuter travel to the CBD faces lower transit travel times than car travel times during the morning peak. While parking restrictions may influence some mode choice decisions for access to the CBD, it is this superior level of accessibility by transit in the morning peak that must be bourn in mind when framing car parking restraint policies. Without high levels of transit accessibility relative to car, car parking restraint policies may have unintended consequences, such as restricting the potential development of locations.

7 Appendix A - Travel time and travel demand databases

Train and bus travel times comprise:

- Access time to nearest station or bus route – this was measured individually for each zone based on street network and centre of development in zone. Access time was calculated using 80 m per minute. Where access entailed more than a 10 minute walk, then it is assumed that an alternative access mode would be used – either park and ride, kiss and ride or bus – in which case access time was estimated using 250 metres per minute (15 km/hr).
- Wait time based on scheduled headways – half the headway capped at 4 minutes was used as an estimate of the wait time
- In-vehicle time was taken from the station/bus route to relevant CBD entry point from published timetables for the morning peak hour (City Rail, 2006; STA, 2006; Westbus, 2006; Forest Coach Lines, 2006). For rail lines with mixed stopping patterns, the fastest stopping pattern was used if it had a reasonable frequency per hour and was substantially faster than slower stopping patterns, otherwise a weighted average in-vehicle time was used.
- CBD access module calculated the incremental in-vehicle time and egress time to each zone in the CBD, including rail service changes. Service changes were valued at 4 minutes. No bus service changes were permitted. The minimum access time was then selected.

Weights were applied to reflect estimates of perceived costs:

- Access weight is 1.5
- Wait time weight is 1.5
- In-vehicle times were weighted by unity
- Rail service change weight is 1.5
- Service change is 4 minutes
- Egress weight is 1.5

Transit travel times were prepared for almost all zones on the Cumberland Plain – with some excluded where they are substantially devoid of development – a total of 645 non-CBD origin zones were included in the analysis. Of these, 542 zones for train travel times, 206 zones with bus travel times and 103 with bus and train travel times.

Car travel times were taken from a strategic highway model of the Sydney metropolitan area that is applied in commercially available software (EMME/2). The model is validated against traffic volumes in 2002 and some travel time data. The validation is considered to be reasonable; however, it is a two-hour morning peak model, which is likely to understate the travel times in the peak one hour.

Car access and egress times were assumed to be 1.5 minutes each and a penalty factor of 1.5 was applied to both access and egress times. Therefore, the average perceived total car access and egress travel time was 4.5 minutes.

Table 2 of the journey to work dataset (ABS, 2003a) was used to provide demand estimates for each of the zone pairs for which transit skims were prepared.

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