

Does increased residential density around train stations encourage more environmentally sustainable travel behaviour?

Catherine Ellis¹, Bruno Parolin²

¹Project Officer
Water Smart Australia Section
Commonwealth Department of the Environment, Water, Heritage and the Arts
02 6274 2473 (work) 0438 204 735 (mobile)
catherine.ellis@environment.gov.au, cl.ellis@yahoo.com

²Faculty of the Built Environment
University of New South Wales
Sydney, NSW 2052
02 9385 4399 (work) 02 9385 5270 (fax)
b.parolin@unsw.edu.au

Email for correspondence: cl.ellis@yahoo.com

Abstract

The conventional wisdom of urban and transport planning is that higher density around public transport nodes encourages greater use of public transport services. This study, conducted in 2007, presents an analysis of this view through a survey of the travel behaviour of apartment dwellers living near train stations on the Sydney rail network. Travel behaviour at the current and previous residence was examined and compared. Results showed that occupants of apartments around train stations had higher public transport use than Sydney-siders in general. However, public transport use did not substantially increase upon moving into an apartment located close to a train station.

The study concluded that, in the case of our respondents, people already oriented towards public transport use were moving to locations with good public transport access in order to continue this travel behaviour. This created an apparent, not actual, influence of urban form and public transport access on public transports. Interestingly car use did decrease at the current residence as trips which were previously taken by car, primarily for shopping, were converted to walking trips. This suggests that proximity to amenities, facilitated by mixed land use, can influence travel to increase walking trips – a desirable environmental outcome. The study also found that a wide variety of variables other land use and access to public transport were statistically and significantly related to travel behaviour including: public transport levels of service, car ownership, parking availability and personal attitudes. Our findings are discussed in relation to current policy that promotes increases in density around public transport nodes.

1. Introduction

There is an extensive body of international and Australian literature on the relationship between urban form and travel behaviour. Conventional wisdom is that increasing residential density results in more sustainable travel behaviour which has been supported by findings

from a number of key studies (Cervero and Kockelman, 1997; Holden, 2006; Newman and Kenworthy, 1999; Soltani and Allan, 2004). Based on these findings policies of increasing density around public transport nodes have been implemented in the belief that they will result in an increase in public transport use. However it has been suggested that simplicity of conventional wisdom has ignored the complexity of the relationship between urban form, travel behaviour and other variables. Rickwood and Glazebrook (2009) suggest that examination of density alone is likely to overstate its effect on travel behaviour.

Conventional wisdom suggests that urban form influences travel behaviour in several ways. Higher residential densities and greater land-use mix reduces the distance between activities, thus facilitating walking and cycling (Cervero and Kockelman, 1997; Newman and Kenworthy, 1992). The greater number of potential passengers in denser areas allows a higher level of public transport service to be efficiently provided (Stead *et al.*, 2000), therefore increasing the convenience of public transport (Soltani and Allan, 2004). High density developments with a mix of land uses increase the range of travel options and, it is argued, this encourages the use of environmentally sustainable modes of travel by increasing their availability and convenience (Krizek, 2003).

Many empirical studies on urban form and travel have found that residents of denser and more mixed land-use areas undertake less travel by car and more by walking and using public transport (Handy *et al.*, 2005). There are differing opinions, however, on whether urban form is the primary influence on travel behaviour as other factors can also influence travel, perhaps to a greater extent than urban form (Badoe and Miller, 2000). Age, gender, income, the presence of children in the household, factors about the home and trip destinations, such as distance from a train station and parking availability, and personal attitudes all play a role in shaping travel behaviour (Gardner and Abraham, 2006; Jarvis, 2003; Kitamura *et al.*, 1997). The level of public transport service available in an area is a seemingly obvious factor potentially influencing travel behaviour, but one that is rarely examined (Badoe and Miller, 2000).

Car ownership and the ability to drive influences travel through increased mode choice. Car ownership also tends to produce a *perceived* need for the car (Cullinane and Cullinane, 2003). Travel habits using the car have also been found to be more stable than for other modes (Thøgersen, 2006) further increasing car use when a car is available.

The distance needed to travel to reach a main public transport stop can influence whether public transport is used; the closer a person lives to a train station the more likely they are to use the train for their travel (Cervero, 1994). This connection is particularly strong for the journey to work (Lund *et al.*, 2003). The distance a person has to travel from a major public transport stop to their destination and whether the destination has ample parking available influences the convenience of the car compared to public transport (Cervero, 2002). Some studies have found that characteristics of the destination can be more important in determining travel behaviour than those of the home end of the trip (Cervero, 2002).

Attitudes to travel can also influence behaviour but are rarely considered in studies that assess the influence of urban form (Handy *et al.*, 2005). When attitudes have been examined they have been found to have a significant influence. In some cases travel patterns thought to be the result of urban form were found to be more strongly influenced by the attitudes of the residents (Kitamura *et al.*, 1997). These results provide evidence for residential self-selection, where individuals choose their home locations based on their travel preferences (Handy *et al.*, 2005). Residents who prefer to walk and use public transport are more likely to choose to live in a denser neighbourhood where many services, such as retail shops, are within walking distance and public transport is frequent and easily accessible (Krizek, 2003).

The New South Wales (NSW) Government is encouraging high density development around selected centres well serviced by public transport through policies outlined in the Metropolitan Strategy (NSW Government, 2005), the Transport Strategy (NSW Government, 2003) and the Metropolitan Transport Plan (NSW Government, 2010a). Through these policies the NSW Government is hoping to “influence travel choice to encourage more sustainable travel” and states that “integrating land use and transport by focusing activities in centres and corridors is the best way to influence people’s choices about where they live, work and travel to services and activities” (NSW Government, 2005, p.181). More recently, in the Metropolitan Transport Plan, the NSW Government has stated that it is seeking to “promote mixed use and appropriate high density uses within walking distance of public transport infrastructure” (NSW Government, 2010a). Implicit in these planning strategies is the assumption that urban form - density in particular - has an impact on travel behaviour.

The purpose of this study is to examine the nature of the relationships, if any, between higher residential density at public transport nodes and travel behaviour by persons who reside within close proximity of such nodes. .

2. The Survey

In order to examine the influence of density and access to public transport on travel behaviour, residents living in multi-storey apartment blocks within 200 metres of fourteen train stations on the Sydney CityRail network were surveyed at the beginning of 2007. Survey locations are shown in Figure 1. A preliminary examination of apartments near train stations along these corridors identified possible stations which had sufficient numbers of multi-story apartment blocks within 200 metres of the station. Fourteen stations were then selected which had a wide spatial spread and a variety of local factors as shown in Table 1.

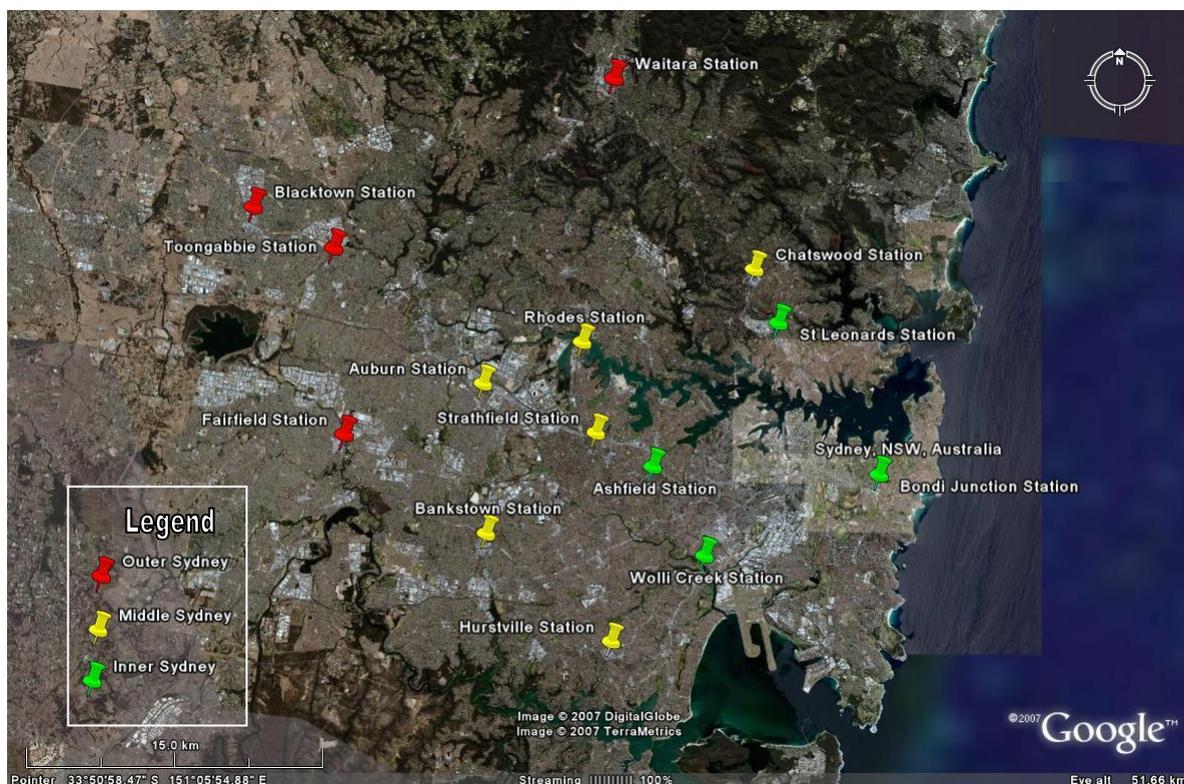


Image source: Google Earth, 2007

Figure 1 Locations of the fourteen stations around which residents were surveyed.

The survey used in the study was designed to provide a description of travel behaviour of each respondent at the current and previous residence for certain trip purposes and

information on factors which could potentially influence that travel behaviour. To gain a picture of travel behaviour questions were asked about the modes used and frequency of public transport use for three trip purposes – travel to work, education and grocery shopping.

Questions were also asked about a range of factors which may have influenced this travel behaviour. This included socio-economic factors such as gender, age and income. Details about the current and previous residences were also sought such as car ownership, parking availability and household make-up. Details about the nature of the previous residence such as type of dwelling and distance to the closest train station were also obtained. Respondents were also asked about their opinion of public transport at both their current and previous residence and whether proximity to the train station was a factor in their decision to move to their current residence. Factors which could influence the journey to work were also examined such as the availability of parking at the place of employment and whether it was within walking distance of a train station, whether a car is needed for work and whether a company car was available.

Due to time and resource restrictions, and the need to keep the survey short to increase the likelihood of return, only the trip purposes of work, education and grocery shopping were examined. These trip purposes were chosen because the trip destinations and modes used tend to be fairly stable, thus allowing an accurate indication of normal travel behaviour to be collected. These trip purposes represented approximately a third of travel in Sydney in 2006 (Transportation and Population Data Centre, 2006) but they were not the main trip purposes. The largest trip purpose in Sydney was actually for social/recreation activities (Transportation and Population Data Centre, 2006). However, the irregularity of these trips would make an overall picture of travel for this purpose difficult to obtain in a short survey and it was therefore not included.

There are several limitations of this survey method, particularly the reliance on the respondents to provide accurate information about past behaviour. The design of this survey may have influenced the responses, as in several sections respondents were asked to answer each question in relation to their current residence and their previous residence side-by-side. This may have increased the number of respondents who indicated that their travel behaviour or opinions did not change.

Surveys were hand delivered to all letter boxes (all residents) in all apartment blocks within 200 metres of the fourteen selected train stations (Table 1). Only one apartment block was not able to be accessed due to security restrictions. A total of 2,496 individual apartments received the survey. The train stations themselves were selected to reflect the Sydney Metropolitan Strategy (NSW Government, 2005) focus on a hierarchy of centres, as well as a variety of other factors such as the presence of supermarkets, distance to Central Station, location of the rail corridor and frequency of train services.

Table 1: Aspects of the survey locations

Train station	Rail Corridor	Distance from Town Hall station (kms)	Average time to Central by train (minutes)	Average number of trains per hour	Supermarket within 500 metres of station?
St Leonards	North Shore	6	21	13	yes
Chatswood	North Shore	9	27	13	yes
Waitara	North Shore	20	49	9	no
Bondi Junction	Southeast	4	15	12	yes
Wolli Creek	Southeast	8	15	22	yes
Hurstville	Southeast	14	23	18	yes
Bankstown	Southwest	17	35	7	yes
Fairfield	Southwest	23	48	7	yes
Strathfield	Western	10	18	49	yes
Rhodes	Western	12	26	5	no
Ashfield	Western	16	14	13	yes
Auburn	Western	16	31	10	yes
Toongabbie	Western	25	42	5	yes
Blacktown	Western	30	40	15	yes

It should be made clear that the Metropolitan Strategy interpretation of a hierarchy of centres is not just train stations. The Draft Subregional Strategies (available at www.metrostrategy.nsw.gov.au) identify the hierarchy of centres (strategic centres and local centres) in each subregion. Of our selected train stations: Hurstville, Chatswood, Bankstown, Blacktown and Bondi Junction are Major Centres, Auburn is a Town Centre and Waitara and Wolli Creek are Villages. In the Metropolitan Strategy 80% of new housing is to be located in the hierarchy of centres (meaning both Strategic Centres including Global Sydney, Regional cities, Major Centres and Specialised Centres, and local centres including Towns, Villages and Neighbourhoods), and new housing is to be located to improve a subregion's performance on the State Plan Priority E5 target to increase the proportion of people living within 30 minutes by public transport of a Strategic Centre (NSW Government, 2005).

3. Results

3.1 Sample characteristics

A total of 172 out of 2,496 distributed surveys were returned, giving a response rate of approximately seven percent. Sixteen respondents (9.3%) were excluded as their previous residence was an apartment within 200 metres of a train station. This left a sample size of 156 respondents.

The majority of respondents were between 18 and 40 years of age (58.9%) and there is a fairly even split between males and females (Table 2). The majority of the sample had an income of above \$40,000 a year (84%). Almost half the sample lived in a two person household (49.4%) and the majority lived in households with no household members aged 18 years or under (82.1%).

Almost all respondents were able to park within their apartment complex (99%). The majority of respondents (87.9%) indicated that the selection of their current residence was, to some degree, influenced by its proximity to a train station and over half of these respondents (55.5%) indicated this was because they preferred to use public transport for their travel. Slightly less than half of respondents lived in an apartment at their previous address (44.2%) and exactly half of respondents estimated that they had previously lived between 200m and 1km from a train station.

At both the current and previous residence the largest proportion of households owned one car (62% and 45% respectively). Over half the respondents (56%) had no change in the number of cars in their household between the current and previous residence. However, of those who did change the majority decreased their household car ownership (36% of the total number of respondents). At both the current and previous homes between 70% and 75% of respondents indicated they had both a drivers licence and daily access to a car, thereby indicating that they had the option of using a car for their daily travel, described as “car access”.

Table 2: Characteristics of the sample

Characteristic	Categories	Percentage of sample (N=156*)
Age of respondent	Under 18	0.6%
	18 to 30	30.1%
	31 to 40	28.8%
	41 to 50	10.9%
	51 to 60	10.3%
	over 60	19.2%
Gender of respondent	Male	48.7%
	Female	51.3%
Income of respondent or main income earner in the household (before tax)	less than \$10,000	4.7%
	\$10,001 to \$20,000	6.0%
	\$20,001 to \$30,000	4.7%
	\$30,001 to \$40,000	10.7%
	\$40,001 to \$60,000	26.0%
	\$60,001 to \$100,000	31.3%
	\$100,00 or more	16.7%
Total number of people in the household	1 person	18.6%
	2 people	49.4%
	3 people	23.1%
	4 people	5.8%
	5 people	3.2%
Does the household contain children 12 years and under?	Yes	15.4%
	No	84.6%
Does the household contain children 18 years and under?	Yes	17.9%
	No	82.1%

* In some categories the total is slightly lower due to non response.

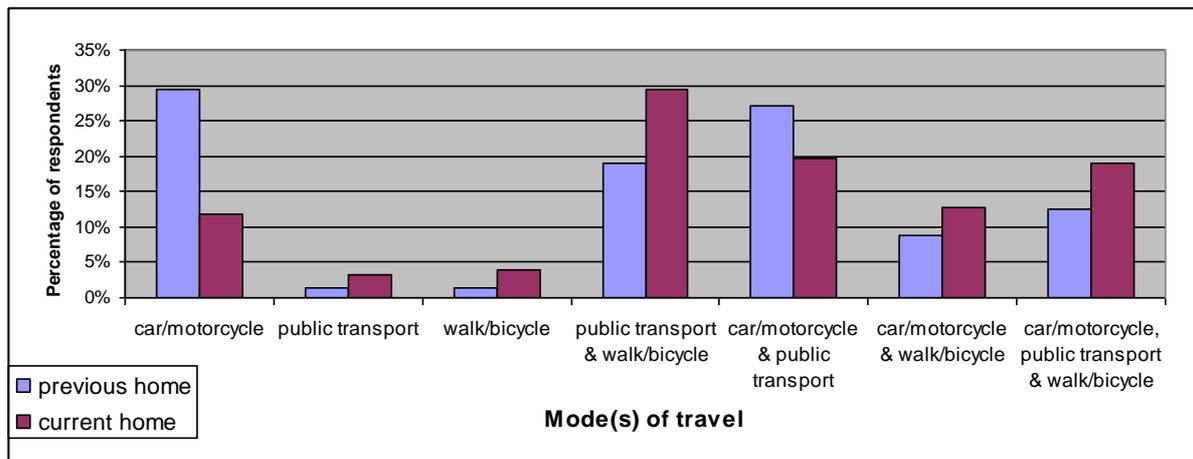
The respondents' opinion of public transport at the current residence was found to be relatively positive for the three aspects covered in the survey: frequency (73% rated it good or excellent), on-time running (80% said most of the time/always), and ease of use in reaching regular destinations (75% said easy/very easy). The opinion of public transport at

the previous residence was less positive: frequency (49% rated it good or excellent), on-time running (60% said most of the time/always), and ease of use in reaching regular destinations (48% said easy/very easy). The majority of respondents (56.2%) indicated an increase in their overall opinion of public transport following a move to their current residence. Only a small number (15%) developed a less positive opinion upon moving to their current residence.

3.2 Travel undertaken by respondents

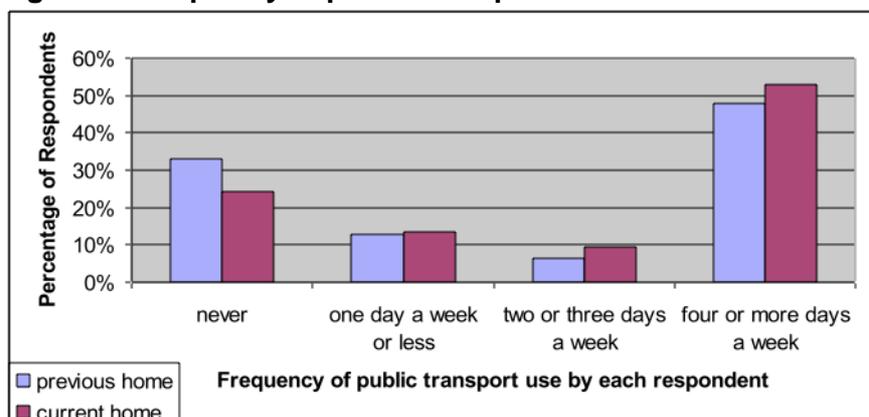
The mode(s) of travel used by respondents and the frequency of public transport use at the current and previous residence for all trip purposes combined are shown in Figures 2 and 3. Only respondents who undertook at least two of the three trip purposes investigated were included in these figures. The data on modes used was obtained from the survey questions that asked respondents to identify which mode(s) they normally use for each of the three trip purposes. The data on frequency of public transport use was gained from the questions on how often public transport is used for each of the three trip purposes.

Figure 2: Mode combinations used by respondents



The dominant modes of travel at the current residence is a combination of public transport and walking (Figure 2). Less than 15% of respondents used the car for all the travel examined at their current residence. At the previous residence, however, respondents who only used the car for the three trip purposes examined represent almost 30% of the sample. Those who used both “car/motorcycle and public transport” represent 46% of respondents (Figure 2). About 50% of the sample of respondents use public transport most days of the week across the trip purposes examined in this study (Figure 3).

Figure 3: Frequency of public transport use



Significant differences were found in travel behaviour for each of the three trip purposes examined in the study as shown in Table 3. In terms of mode choice, public transport was the dominant mode for travel to work and education at both the current and previous residence. The car represented a larger proportion for the journey to work compared with travel for education, which was slightly more dominated by the environmentally friendly modes of public transport and walking/bicycling. Travel for grocery shopping was very different in terms of mode use, with public transport representing 5% or less at both the current and previous homes. At the previous residence the car is the dominant mode for grocery shopping whereas walking is dominant at the current residence.

Table 3: Travel mode combinations by trip purpose

Main mode(s)	Work		Education		Grocery shopping	
	Previous residence	Current residence	Previous residence	Current residence	Previous residence	Current residence
Car/motorcycle	37%	24%	25%	19%	59%	33%
Public Transport	44%	56%	50%	62%	5%	4%
Walk/bicycle	4%	8%	14%	4%	24%	48%
Car/motorcycle & public transport	15%	10%	11%	15%	3%	1%
Car/motorcycle & walk/bicycle	<1%	3%	<1%	0%	10%	15%

Table 4: Frequency of public transport use for travel to work and education

Frequency of public transport use	Work		Education	
	Previous residence	Current residence	Previous residence	Current residence
Four days a week or more	47%	51%	35%	44%
Two or three days a week	5%	9%	21%	19%
One day a week or less	12%	11%	12%	22%
Never	36%	30%	33%	15%

3.2.1 Change in Travel

Examination of the change in car use upon moving to the current residence showed that almost 50% of respondents had no change in their use of the car for the three travel purposes examined based on whether or not they used their car (Figure 4). Forty percent of respondents decreased their car use, showing that for at least one trip purpose the respondent used the car at the previous residence but uses a different mode at the current residence.

Change in the frequency of public transport use was also examined (Figure 5). As with car use the largest group of respondents, 46%, experienced no change in their frequency of public transport use and 29% actually decreased their frequency of public transport use – contrary to what might have been expected.

Figure 4: Change in car use

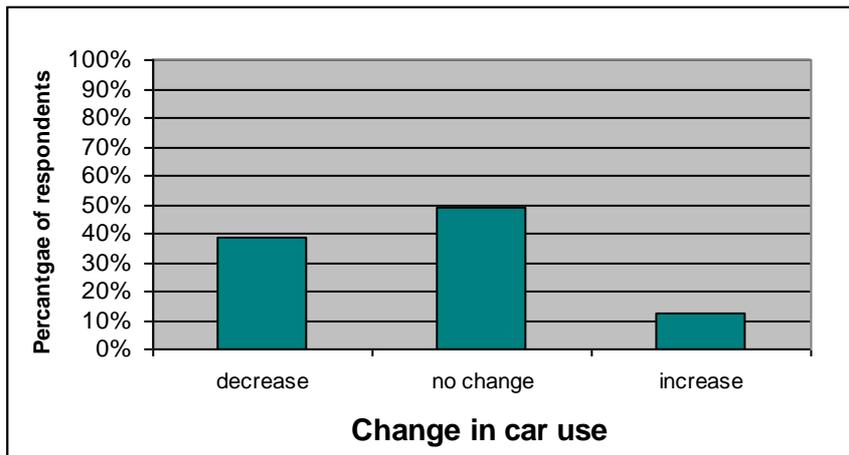
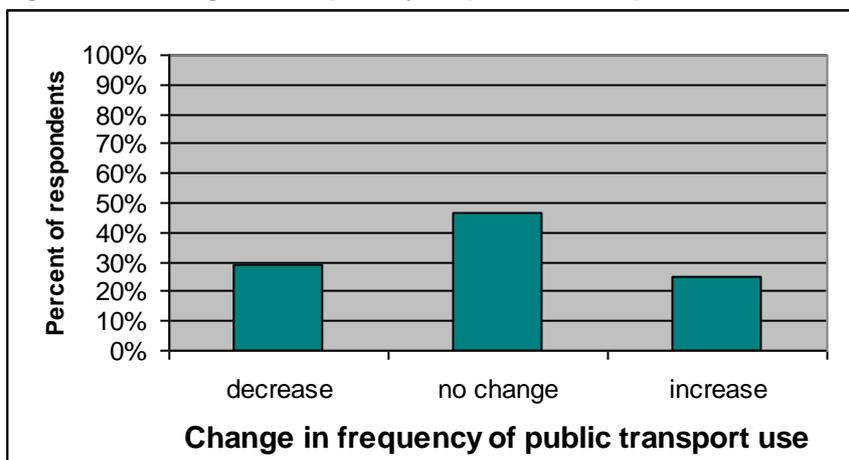


Figure 5: Change in frequency of public transport use



In terms of travel for the individual trip purposes examined the most significant change (as shown in Table 4) was a reduction in car use for grocery shopping, where car trips were replaced with walking trips. For both car use and frequency of public transport use, the majority of respondents reported no change in their travel behaviour for the journey to work. Forty percent of respondents did not change their level of car use or frequency of public transport use for the journey to education. An increase in the frequency of public transport use between the current and previous residents is seen for travel to education but is minimal for travel to work.

3.3 Variables affecting change in travel behaviour

The relationship between travel behaviour and potentially influential variables was examined through cross-tabulations and chi-square analysis. Statistically significant relationships were found between change in travel and: dwelling type, distance to the train station at the previous residence and the presence of a supermarket within 500 metres of the train station at the current residence. However, given the small sample size for analysis and the sparse data problem in our cross-classified data, the absence of a statistically significant association with other variables should not be considered as evidence that a particular variable is not influential on travel behaviour.

Respondents who lived in a house at their previous residence were much more likely to have decreased their car use for overall travel ($p=0.000$, $df=2$) and for grocery shopping ($p=0.019$, $df=2$) compared to those who lived in an apartment. Respondents who lived a

longer distance from a train station at their previous residence and have, therefore, now moved substantially closer to a train station were more likely to have decreased their car use than those who lived closer to the train station at their previous residence ($p=0.001$, $df=2$). The presence of a supermarket within 500m of the current residence was also found to have a significant influence on the overall change in car use ($p=0.044$, $df=2$) and the change in car use for shopping ($p=0.000$, $df=2$). If there is a supermarket within 500 metres of the train station next to which respondents now reside they were more likely to have decreased their car use. No statistically significant relationship was found with changes in frequency of public transport use.

No significant relationships were found between change in travel behaviour and: gender; income; household size or presence of children in the household; the respondent's opinions about public transport; public transport levels of service; aspects of the location of the current residence; car ownership; and opinion of public transport.

3.4 Variables related to travel at the current and previous residence

As discussed few variables were found to be statistically related to the observed change in travel. Statistically significant relationships were found between travel behaviour at either the current or previous residence and a range of other variables but the direction of influence cannot be reliably identified. These findings are discussed below but directions of influence should not be assumed.

Age at the current residence was found to have a statistically significant association with the frequency of public transport use ($p=0.014$, $df=2$) with respondents 30 years old and younger using public transport more frequently for their overall travel. No other statistically significant relationships were found for other socio-economic variables examined in the study.

Significant associations were found between previous travel patterns and aspects of the previous residence. People who lived in a house at their previous residence were less likely than those who lived in an apartment to use public transport to travel to work ($p=0.003$, $df=1$) at the previous residence. Those who lived far away from a train station at their previous residence were more likely to use the car for the journey to work ($p=0.004$, $df=2$). No statistically significant relationships were found between travel behaviour and aspects of the current residence such as distance from the Sydney CBD, zone location within Sydney as defined by the Australian Bureau of Statistics and the train corridor.

The respondent's opinions of public transport was significantly related to travel behaviour at both the current and previous residence. Respondents who felt public transport was easy to use to reach their regular destination were more likely to use public transport frequently at both the previous and current residence for overall travel (current residence: $p=0.002$, $df=2$, previous residence: $p=0.001$, $df=4$) and for their journey to work (current residence: $p=0.000$, $df=2$, previous residence: $p=0.003$, $df=2$). They were also less likely to use the car to reach their place of employment at both the previous and current residence (current residence: $p=0.000$, $df=2$, previous residence: $p=0.001$, $df=2$).

At the current residence, but not at the previous residence, the respondents' opinion of how often public transport services in their area run on time was significantly related to mode use ($p=0.021$, $df=1$) and the frequency of public transport use ($p=0.009$, $df=1$) for the journey to work. The respondent's combined score, indicating their overall opinion of public transport at the current residence, was also significantly related to mode use ($p=0.001$, $df=2$) and frequency of public transport use ($p=0.000$, $df=2$) for the journey to work.

The importance to the respondents of close proximity to a train station in the selection of the current residence provides an indication of how important the respondent felt public transport use was for their travel, and this was found to be significantly related to travel behaviour at the current residence. Respondents whose selection of their current residence had been influenced by proximity to a train station were more likely to use public transport more frequently for overall travel at the current residence ($p=0.000$, $df=2$). For the journey to work they were also more likely to use public transport frequently ($p=0.000$, $df=2$), and less likely to use the car ($p=0.000$, $df=2$).

Public Transport use at the previous residence was also significantly related to how important respondents felt the distance to the train station was in the selection of their current residence. Respondents who used public transport frequently in their overall travel, and travel to work at their previous residence, were more likely to have indicated that distance to the train station was “very important” when selecting their current residence ($p=0.002$, $df=2$ and $p=0.007$, $df=2$ respectively).

At the current residence respondents who live next to train stations with a higher level of service are more likely to use public transport instead of the car for the journey to work ($p=0.027$, $df=2$). No statistically significant relationship was found for overall travel. We have measured train level of service by the number of trains per hour averaged over a 24 hour weekday. It is recognised that this measure is strongly influenced by train services provided during peak periods of the day when most of the work and education trips of our sample of respondents would have been undertaken.

The absence of a car in the household significantly increased the frequency of public transport use at both the current and previous residence. If there was at least one car in the household the respondent was less likely to use public transport frequently (current home: $p=0.022$, $df=2$, previous home: $p=0.000$, $df=3$) and more likely to use the car for the journey to work (current home: $p=0.002$, $df=2$, previous home: $p=0.002$, $df=2$). At the previous residence the effect on the journey to work became stronger as the number of cars increased.

Having “car access” at both the current and previous residence was negatively related to frequency of public transport use both for overall travel (current residence: $p=0.007$, $df=1$, previous residence: $p=0.000$, $df=1$) and for the journey to work (current residence: $p=0.025$, $df=1$, previous residence: $p=0.001$, $df=1$). It was also positively related to car use for the journey to work (current residence: $p=0.006$, $df=1$, previous residence: $p=0.000$, $df=1$).

3.5 Variables related to the journey to work

Aspects of the place of employment were found to be statistically significantly related to travel behaviour for the journey to work. If the place of employment was within walking distance of a train station the frequency of public transport use increased (current home: $p=0.003$, $df=1$, previous home: $p=0.000$, $df=1$) and the likelihood of using the car decreased for the journey to work (current home: $p=0.000$, $df=1$, previous home: $p=0.000$, $df=1$). It is interesting to note that only 6% of respondents at the current residence and 7% of those at the previous residence still used public transport when their place of employment was not within walking distance of a train station. Over 15% of respondents at the current residence and over 20% at the previous residence said their place of employment was within walking distance of a train station but still used the car for their journey to work.

The availability of parking in general, and the availability of free parking specifically, were both negatively related to public transport use for the journey to work ($p=0.005$, $df=1$ and $p=0.018$, $df=1$ respectively) and increased the likelihood of using the car ($p=0.002$, $df=1$ and $p=0.000$, $df=1$ respectively). A large portion of respondents, over 63% at the current

residence, and 55% at the previous residence, indicated that their place of work had parking available and was within walking distance of a train station.

Differences in travel times between the modes were also significantly related to the mode used for the journey to work (current home: $p=0.000$, $df=1$, previous home: $p=0.000$, $df=1$). People were more likely to use the mode which was quicker, however, the strength of the effect differed between the modes. Only 1% of the sample indicated that public transport was faster but still used the car for this trip, whereas almost 20% of the sample indicated that the car was faster but used public transport.

Access to a company car ($p=0.046$, $df=1$) and whether a car was needed for work purposes ($p=0.000$, $df=1$) were found to be significantly related to travel for the journey to work at the previous residence only, both were found to be positively related to car use and negatively related to public transport use. The absence of an effect at the current residence could indicate that improved access to public transport suppressed these other influences.

The distance from the home to the “usual” grocery shopping location, as defined by the respondents, was significantly related to the mode used for this trip. If the usual place of grocery shopping was within walking distance of the residence this significantly increased the number of respondents who walked and decreased the number who drove to do their shopping (current residence: $p=0.000$, $df=2$, previous residence: $p=0.000$, $df=2$).

4. Discussion

As expected, travel at the current residence, an apartment close to a train station, was found to be dominated by the environmentally friendly modes of public transport and walking/cycling. However, travel at the previous home was also fairly environmentally friendly with the majority of respondents using public transport and walking/cycling. There were more respondents at the previous residence though who only used the car for the trip purposes examined,

Anecdotal evidence suggests that public transport use by the respondents in the current study is higher than average for Sydneysiders in general. A more direct comparison is possible for the journey to work: the Transport and Population Data Centre (2006) reported that in 2004 only 20 percent of travel to work in Sydney was undertaken by public transport. In the current study 56 percent and 44 percent of respondents at the current and previous residences, respectively, indicated they use only public transport for their travel to work.

These results provide evidence of the occurrence of residential self-selection in these higher density developments. Respondents who already used public transport for much of their travel chose to move closer to a train station in order to maintain this travel pattern. The higher levels of public transport use found in denser areas well serviced by public transport, which is reported in other studies may therefore be due to residential self-selection.

It is interesting to note though that at the current residence, where respondents live within 200 meters of a train station, over 20 percent still indicated they never use public transport for the three trip purposes examined. This suggests that factors other than access to public transport and density are influencing travel behaviour. A similar finding was made by Cervero (1994) who examined the travel patterns of residents who lived in apartments within easy walking distance of train stations and found that only 15 percent of the main trips were train trips. The majority of respondents in Cervero’s study (1994) were still reliant on their car for the majority of their travel despite living near a train station.

4.1 Variables affecting change in travel

The change in travel behaviour observed between the previous and current residences was not extensive, with the largest group of respondents experiencing no change in car use or the frequency of public transport use. Although some positive change in travel behaviour occurred, the change is not as extensive as expected.

This study found that moving into an apartment from a house, which can be used as a proxy for moving into an area with higher residential density, reduced car use - a desirable environmental outcome, but did not impact upon frequency of public transport use. The reduction in car use was primarily due to grocery trips being converted from car trips to walking trips at the current residence. This suggests that the observed impact of density on travel may actually be because density can be a proxy for land use mix. This is supported by the finding in this study that the presence of a supermarket within 500m of the train station at the current home, an indication of land use mix, was statistically and significantly related to a decrease in car use. Handy et al. (2005) also found that the number of supermarkets and pharmacies within an area increased the likelihood of a reduction in car use upon moving into the area. Kitamura et al. (1997) found land-use mix played a role in the generation of public transport and non-motorised trips. These results highlight the importance of land-use mix, particularly the presence of retailing, within new residential developments.

The large percentage of respondents who never used public transport for grocery shopping at both the current and previous residence (89% and 87% respectively) demonstrates that this is not a preferred mode for this trip purpose. This reinforces the importance of land-use mix to ensure shops are within walking distance of the home. If local shops are not easily accessible by walking the majority of people will choose the car over public transport for this trip.

Distance to the train station at the previous residence was also found to influence the change in car use. Respondents who lived a large distance from the train station at their previous residence and had therefore moved substantially closer to the train station were more likely to reduce their car use. However, no relationship was found with change in frequency of public transport use.

These results suggest that increasing residential density around train stations will encourage public transport use and decrease car use, consistent with NSW Government policies (1998, 2005); however, as observed in the current study the actual change in travel this produces may be minimal.

4.1 Variables related to travel behaviour at the current and previous residence

The following section discusses variables which were found to be statistically and significantly related to travel behaviour at either the current or previous residence and the potential implications of these for policy makers. However, the direction of influence often cannot be identified. The small change in travel behaviour which was found in the current study could have masked the influence of these variables on change in travel behaviour.

4.1.3 Car ownership and access

As would be expected car ownership and having “car access¹” was statistically associated with less frequent public transport use. Many other studies have found car ownership to have a significant influence on travel behaviour (Cervero, 2002, Kitamura et al., 1997, Rajamani et al., 2003).

¹ indicating that respondents had both a drivers licence and daily access to a car

As interesting finding of the current study was that “car access” did not decrease upon moving to the current residence. Despite moving to a location with good access to public transport most respondents still maintained the option of using the car. The alternatives to car travel provided at the current residence were therefore not sufficiently convenient for respondents to feel they no longer needed a car for their travel or factors other than public transport access were influencing mode choice.

Lund et al. (2003) concluded from their study of developments in close proximity to train stations that the full benefit of these types of developments will only be realised when the travel alternatives provided, such as frequent public transport and activities within walking distance, allow residents to reduce car ownership without feeling they have lost mobility.

Gardner and Abraham (2006) and Cullinane and Cullinane (2003) found that car ownership tended to result in perceived car dependence and therefore car dominance in travel, even when travel alternatives were available. Parking availability at the home facilitates car ownership and has also been found to directly encourage car trips in previous studies (Kitamura et al., 1997). In the current study, 99 percent of respondents reported that parking was available within their apartment complex at the current residence despite being located in close proximity to a train station. This suggests an underlying assumption that the residents of these developments are likely to be automobile oriented.

Through the development approvals process and setting of standards for residential developments governments can influence the availability of residential parking to reduce it in locations well serviced by public transport. This can reduce car ownership and encourage residents to use the other more sustainable travel options available.

4.1.5 Factors around Public Transport

Public transport levels of service were also found to have an influence on the mode(s) used for the journey to work. Respondents living next to a train station with a higher number of trains per hour (averaged over 24 hours on a weekday) were more likely to use public transport for the journey to work. This demonstrates the importance of providing high levels of public transport service in increasing public transport patronage.

The respondents’ opinion of public transport services in their area was found to be statistically related to their use of public transport. Their opinion of the ease with which they could use public transport to reach their regular destinations was found to be a good predictor of public transport use, as it was highly significantly related to measures of overall travel and travel to work at both the current and previous residence.

Measures to increase the perceived convenience of public transport therefore have the potential to increase its level of use. Increasing levels of service and other measures to increase the convenience of public transport are likely to lead to improved public perceptions of public transport and, therefore, to a higher propensity for public transport trip making. Effective advertising and ensuring easy access to trip and timetable information can combat negative opinions of public transport, particularly when these are based on incorrect assumptions or biases.

4.1.8 Location of employment centres and parking availability

The distance from the place of employment to the nearest train station was statistically related to travel behaviour. Less than 8 percent of respondents at the current and previous residence indicated they still used public transport when their place of employment was not within walking distance of a train station.

If employment locations are established in areas not well serviced by public transport this will reduce the percentage of employees using public transport for the journey to work. The Transportation Research Board (1996) also found that the probability of using public transport, for any trip purpose, is dramatically increased if both the trip origin and destination are within close proximity to a train station. Increasing residential densities needs to be supported by employment location, which is also a strong focus of the Sydney Metropolitan Strategy which supports the set of Strategic Centres increasing their share of total jobs (NSW Government, 2005).

However, in the current study 18 percent of respondents at the current residence still used the car for their journey to work when their place of employment was within walking distance of a train station. Despite the origin and destination of the journey to work being in close proximity to a train station other factors were influential enough to discourage public transport use.

The current study also examined the influence of the availability of parking at the place of employment and found that having parking available significantly increased the likelihood of the respondent driving to work. Decreasing parking availability in employment centres well serviced by public transport is therefore likely to reduce car use for the journey to work. This is consistent with current government policy (Integrating Land Use and Transport – A Planning Policy Package, NSW Government, 2010b), and with the intent of the new Metropolitan Parking Policy which is being developed as an action in the Sydney Metropolitan Strategy (NSW Government, 2010a).

Several other studies, such as Lund et al. (2003) and Cervero (1994), found the same effect of parking, and particularly free parking, at the place of employment on the travel patterns of residents who lived close to a train station. Cervero (1994) found the availability of free parking at the workplace to be the strongest predictor of the mode choice for this trip.

4.1.9 Travel time

Whether the journey to work was faster by car or public transport was also found to be significantly related to the modes used for this trip and is another aspect of the relative convenience of modes. Respondents were more likely to use the mode which was quickest and, as was also found by Lund et al. (2003), this had a greater influence on public transport use compared to car use.

When our respondents were asked to compare travel time of different modes only 1 percent indicated that public transport was faster but still used the car. Reduced travel time is therefore a strong encouragement for public transport use. This is supported by Lund et al (2003) who found that Californian residents of residential developments in close proximity to train stations were more likely to choose to use public transport over the car for their journey to work if using the car presented less of a travel time advantage (Lund et al., 2003).

Policies aimed at decreasing public transport travel time, for example increasing levels of service, improving connections between services, extending bus lanes and bus priority at traffic lights are likely to be successful at increasing public transport patronage. However, policies which decrease travel time by car, such as the construction of freeways, will reduce the effectiveness of these measures.

5. Conclusion

The results of this study, while based on a limited sample size, suggest that increasing density around public transport nodes is not likely to produce a significant increase in the frequency of public transport use. A high level of public transport use by residents of the developments around public transport centres is observed in this study, but there was little

change in the frequency of public transport use upon moving to the current residence for the three trip purposes examined. The majority of respondents were already frequent public transport users at their previous residence and this influenced their decision to move into a location close to a train station. Although both changes in density and distance to a train station were found to significantly influence change in travel behaviour the actual change observed was minimal. The largest group of respondents experienced no change in their travel behaviour for the three trip purposes examined.

A decrease in car use, mainly due to car trips for grocery shopping being converted to walking trips was observed in our sample of respondents. Ensuring land use mix in these new developments is therefore important to encourage walking trips. While this is for a relatively minor trip purpose amongst our sample it has generated an environmentally desirable outcome. This study also found that a range of other factors were related to travel behaviour, including: parking availability; car ownership; public transport level of service; the perceived convenience of public transport; and the relative travel time of different modes.

The results of this study suggest that the policies of the Sydney Metropolitan Strategy (NSW Government, 2005) and the Metropolitan Transport Plan (NSW Government, 2010a) to encourage higher residential density around public transport nodes is unlikely, in isolation, to produce a substantial change in travel behaviour. In order to successfully bring about the desired change in travel behaviour the significance of other influential must be recognised and policies aimed at improving these factors must be used in conjunction with urban development policies.

Further Australian research is required in order to examine influences on travel behaviour for a wider range of trip purposes, especially non-work travel. The use of larger sample sizes is also needed in order to confirm the preliminary results of the present study. We view this research need as important and pressing given the range of strategic urban plans that are being implemented across Australian metropolitan areas. The results of this research should be used to inform the direction or re-direction of these strategies.

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