Vehicle occupancy in New Zealand's three largest urban areas

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ABSTRACT

As in several other countries, vehicle occupancy in New Zealand has been gradually declining. The Government's recently-released Energy Efficiency and Conservation Strategy identifies increasing vehicle occupancy rates as one means of reducing energy use and CO_2 emissions from transport.

Measurements of the vehicle occupancy are often by simple observation of vehicles on the road. Such measurements are naturally unable to relate differences in occupancy to variables such as trip purpose, driver demographics, and so on. Our analysis describes the vehicle occupancy in terms of such variables in New Zealand's three largest urban areas (Auckland, Wellington, Christchurch) by using a large nationwide survey, the New Zealand Travel Survey 1997/98. The analysis is extended, where possible, by linking the driver information to travel information from others in the same household. Hence, contrasting patterns may be found among several different types of vehicle occupancy: single-occupant vehicle, household adult passengers, household child passengers, non-household passengers.

Implications for transport policy are considered, by comparing our results both to overseas research on vehicle occupancy and to our recent stated choice experiments in the same three New Zealand cities. Our stated choice research with morning commuters found a significant effect of trip-time reductions from a high occupancy vehicle lane on car-pooling in Auckland. Mode choice was also affected by other variables related to occupancy, particularly driving children to school.

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1. CONTEXT

It is generally accepted that vehicle occupancy rates in developed countries have been declining for at least the last twenty years. For example, the US Census shows that use of a single occupancy vehicle (SOV) for travel to work increased from 64% in 1980 to 76% in 2000 (Pucher & Renne, 2003). Closer to home, the New Zealand Travel Survey (NZTS) shows average occupancy of 1.75 in 1989/90 (Land Transport Safety Authority, personal communication, 20 June 2003), compared with 1.69 in 1997/98. (The NZ figures weight trips in proportion to distance, exclude vehicle types

other than cars and vans/utes/4-wheel drives, and exclude a small number of trips recording 10 or more occupants[1]).

The reasons for the decline in vehicle occupancy rates are generally attributed to an established set of factors, for example: "In common with many other countries, Australia has experienced declining vehicle occupancy rates as incomes have grown and the real cost of motoring has declined" (Bureau of Transport and Regional Economics, 2003).

Declining vehicle occupancy is clearly seen as one contributor to the increased traffic congestion many medium to large urban centres experience. Indeed, various local authorities (e.g. Greater Wellington Regional Council) regularly monitor occupancy rates and some even set targets to increase occupancy. For example, the Perth Metropolitan Transport Strategy aimed to increase car occupancy from 1.21 in 1991 to 1.25 in 2029, opposing a trend to an occupancy rate of 1.13 by 2029 (James, 1998).

Occupancy is frequently measured by direct observation of vehicles (e.g., by cordon-lines around CBDs). Such measurements do monitor actual occupancy at these particular locations, but they do not allow for the development of much understanding of the reasons behind any occupancy patterns or trends discerned. Such an analysis would entail taking account of differences between drivers (e.g., demographic differences, different trip purposes), as well as passenger types (e.g., children being taken to school).

Using a subset of the NZTS, restricted to the largest New Zealand urban centres (Auckland, Wellington and Christchurch), we have been able to relate the differences in occupancy to variables such as trip purpose, driver demographics and passenger characteristics. Analysis of the relationship between driver characteristics and occupancy is useful to understand both the likely impact of major demographic changes and trends (e.g., population ageing, the changing role of women, decreasing household size) on vehicle occupancy and to better anticipate the impact of policy options such as high occupancy vehicle (HOV) lanes.

Similarly, analysing the relationship between passenger characteristics and occupancy is instructive. For example, the substantial increase in recent years of children being driven to school is generally regarded unfavourably in terms of travel demand management. However, because such trips inevitably involve passengers, they may lead to increased average occupancy (generally regarded favourably). This could be misinterpreted in cordon-line occupancy counts, if an increase or even a slowing of the decline in the vehicle occupancy rate was achieved because more parents drive their children to schools within the cordon area.

Apart from describing the characteristics of vehicle occupancy in the three key urban centres, our paper also considers such policy implications in part by relating this analysis to our recent stated preference study of morning peak period car commuters in the same three New Zealand cities. The experimental design for our stated preference study included factors such as HOV lanes, public transport fares and service levels, cordon tolls, parking restrictions and surcharges.

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[1] Because of the large sample sizes with such surveys, we generally dispense with formal tests of significance as a largely unnecessary formality. For example, the reduction in average occupancy of around 0.06 reported here is not large, but needs to be compared with the margin of error of average occupancy per trip leg which is around 0.008 for the 1997/98 data.

2. METHOD

2.1 INITIAL DATASET

The starting point for this analysis was a subset of the Land Transport Safety Authority (LTSA) 1997/98 Travel Survey database (LTSA, 2000), restricted to key urban centres only (Auckland cities, Wellington cities, Christchurch).

Additional restrictions for analysis of occupancy were:

1. Only households with complete responses from all eligible household members. This prevented passenger trips remaining unmatched to a driver simply because a driver from the same household had not completed the questionnaires, etc.

2. Removed a small number of trip legs with vehicle types Motorbike, Taxi, and Other.

3. Removed 230 trip legs that were 60+ km long. First, most long trips will be on roads outside our urban scope of interest. Second, results from small sub-groups with a few very long trips could be severely affected by extreme values in weighting (to be consistent with occupancy measures taken on the road and good international practice, each trip in occupancy analysis here is usually weighted in proportion to its length).

In summary, the base (unweighted) has:

- 27,851 trip legs -- 18,150 trip legs by drivers, and 9701 trip legs by passengers

- 3467 people (1759 in Auckland; 705 in Wellington; 1003 in Christchurch)

- 1396 households.

Full details about the base sample and other aspects of method such as the matching described next can be found at www.PinnacleResearch.co.nz.

2.2 MATCHING TO ENABLE ANALYSIS OF PASSENGER TYPE

To split total occupancy into major components (household versus non-household passengers; children versus adults), preliminary data processing was necessary. This preliminary work was required because such fine and time-consuming distinctions were not directly recorded by drivers in the survey. Respondents were (often) independently recording key aspects of trips such as the time of departure, hence it was unrealistic to expect matches to the exact minute between different respondents' records of the same trip. In addition, it seemed quite possible that other car occupants on a trip might well remember further minor stops or describe the same address differently. Hence, the matching was done in a way that allowed for some imprecision.

In total, 15 discrete match types taking account of arrival and departure times, vehicle driven, and address were used. Preference was given to exact matches, but imprecision was allowed (e.g., a discrepancy between recorded times was allowed if no better match was found). The hierarchy of matches is summarised briefly in Table 1. In particular, Table 1 shows that **96% of matches found were quite**

precise (match types 0 through 6). It is arguable whether or not we should use the least accurate 5 match types; but their inclusion has little effect overall because they account for only around 1% of the total matches.

Table 1: Final hierarchy of matches

Match type and imprecision		Number	%
0	Perfect match	5265	73.6
1,2	1 Time only	388	5.4
3,4	1 Time & 1 approx Time*	169	2.4
5,6	1 Place & Time	1038	14.5
9	Places	32	0.4
12	Vehicle (but still a household vehicle)	38	0.5
7,8	1 Place, 1 Time & 1 approx Time	164	2.3
13	Vehicle, 2 approx Times	11	0.2
10,11	Places, 1 Time & 1 approx Time	27	0.4
14,15	Vehicle, 1 Time & Place	21	0.3
Total		7153	100.0

Note: Imprecision in "Time" allows discrepancy of any length on the same day, whereas imprecision in "approx Time" restricts the discrepancy to 2 hours maximum (further restricted to only 1 hour for match types 10–15).

Table 2 shows that only 5% fell into the category indicating likely failure of matching ("Not matched, household vehicle"). **Hence, the matching process successfully assigned around 95% of passenger trip legs.** This is not ideal, but seems sufficient given that the main analysis of occupancy will be based on the number of occupants directly recorded by the driver. The bias from failed matches will probably be minimal for two kinds of subsidiary analyses (household children, household adults), but greater for the third kind of subsidiary analysis (non-household passengers). Non-household passengers can only be estimated for each driver trip leg by subtracting the matched passengers from the total number of occupants recorded by the driver. This estimate of non-household passengers will be contaminated by the unmatched trip legs using household vehicles (around 1/5 of the combined total of unmatched trip legs).

Table 2: Extent of matching for passenger trip legs

Match result	Number	%
Matched, household vehicle	7037	72.6
Matched, non-household vehicle	116	1.2
Not matched, household vehicle	448	4.6
Not matched, non-household vehicle	2093	21.6
Total	9694	100.0

2.3 STATISTICAL WEIGHTING

Not all trips are equal, that is, some are distinctly longer than others. Taking account of distance in occupancy analysis is important because of:

- Confounding. In particular, men in our sample reported driving much further on average during the previous year (17,310 km) than women (9263 km). Such a disparity could have confounding effects on analysis of occupancy unless distance is properly accounted for.

- Consistency. It is desirable that analysis of occupancy here be consistent conceptually with total occupancy as commonly observed from the roadside. Other things being equal, those who drive further are more likely to drive through cordon-lines used for observing occupancy.

Hence, our statistical weight multiplies the usual weight[2] by the distance recorded for each trip. Similarly, in later analyses based on results summarised for each driver, the usual weight is multiplied by the total distance driven by the person.

The risk of extreme weighting values from a few very long distances was eliminated by restricting the analysis to trip legs shorter than 60 km long (longer trip legs will generally involve travel outside the urban area of interest here). In addition, we also examined parallel unweighted results for major findings to check that results were not a misleading artefact of weighting.

Note that including distance in the measurement of vehicle occupancy is general practice in the major U.S. trip study (Hu & Young,1999):

> "For NPTS data, vehicle occupancy is generally computed as person miles of travel per vehicle mile (referred to as the travel method)." (p. G-4)

3. RESULTS

3.1 DIFFERENCES RELATED TO TIME, PLACE, AND VEHICLE TYPE

We present these differences briefly, because such differences are also measurable using occupancy measurements by observation from the roadside.

Occupancy is much higher at the weekend than on the weekdays (see

Figure 1). Because of this disparity, we have focused most of the remainder of the paper on weekdays only, to prevent the very different weekend occupancy patterns from confounding the other results presented.

Although less than the disparity between weekends and weekdays, Sundays had higher occupancy than Saturdays. Our separate paper on weekend travel behaviour (O'Fallon & Sullivan, 2003) presents a variety of differences between Saturdays and Sundays, thus warning against assuming that travel patterns are nearly identical on both days.

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[2] The usual weight is based on the person post-stratification weights supplied by the LTSA with the database. This aligns the weighted sample to the estimated population data (derived from Statistics New Zealand Census results) for December 1997 by the same region, age group, and gender classifications. Consistent with LTSA practice for the nationwide sample, we adjusted the person weight so that there was an even distribution of weighted person travel days across the days of the week (our adjustment for this was somewhat different in size although identical in principle because we are analysing a sub-sample only from the three major urban areas).

Figure 1 Occupancy is clearly higher in the weekend
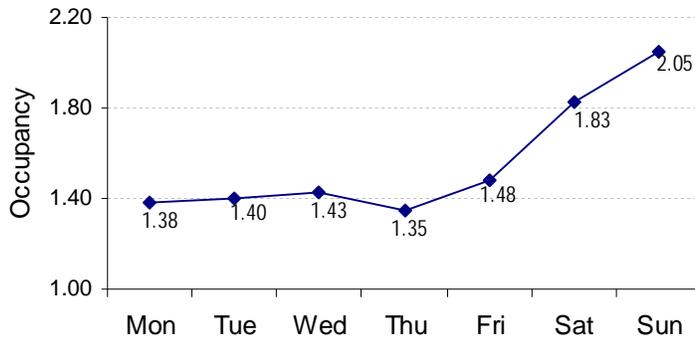
The three urban areas analysed (Auckland, Wellington, Christchurch) differed little in average weekday occupancy (1.39, 1.46, and 1.43 respectively). The average weekday occupancy for all three cities combined is 1.41 (this is close to the Auckland average reported just above, because Auckland has a much larger population than Wellington or Christchurch). Note that these averages appear broadly consistent with occupancy as measured by roadside observation (e.g., the Wellington CBD Cordon Inbound Traffic Occupancy measure taken during the morning peak on a weekday has been showing occupancy around 1.4 since 2000; Kelly, 2002).

Average (weekday) occupancy varies little with respect to the three vehicle types (Car/station wagon, Panel van/van/ute/4-wheel drive, Truck); to one decimal place, occupancy is 1.4 for each type.

Average occupancy is low (1.17) for early trips starting before 7:30 a.m., and increases later during the day (see Table 3). High occupancy (1.61) for trips beginning after 6:30 in the evening is related to the high occupancy we next show is associated with trips for Social/recreational purposes. Average occupancy for trips for Work purposes is consistently low, 1.1 to 1.2 for each of these times a day. In contrast, trips for Social/recreational purposes have consistently higher average occupancy, between 1.4 and 1.9 for each of these times of day.

Table 3: Weekday occupancy is lowest in the early morning and higher in evenings

| Leaving time	Average occupancy
Up to 7:30	1.17
7:30-9:30	1.37
9:30-14:59	1.42
15:00-18:29	1.41
18:30 and later	1.61
All times	1.41

3.2   DRIVER PURPOSE AND CHARACTERISTICS

3.2.1   Trip purpose/destination

Before describing the relationship between trip purpose and occupancy, it is helpful to understand some of the details of the database we have analysed. Trip purpose is recorded from the driver's point of view, hence driving children to school will have purpose "Accompanying someone else", not "Education". If a driver has Education as the trip purpose, then it is his or her own place of study. The trip purpose "Home" is associated with a mixture of the other purposes. Because purpose is measured for each trip leg (i.e., for each stop), returning home from work is assigned the same purpose as returning home from sport. In the few cases where the reason for the trip leg was to "Change to another transport mode" (3.5%), the purpose was taken from the first trip leg with a purpose/destination other than to simply change mode. That is, if someone walked to a railway station in order to catch a train to work, the purpose for the trip leg walked was recorded as Work rather than Change mode.

Trip legs made for functional purposes (Work, Education) had the lowest average occupancy (see Figure 2). Social/recreational trip legs had a much higher average occupancy. Although the results here are for weekdays only, consistent with the focus of this paper, similar differences are apparent on Saturdays and Sundays.

Figure 2   Work/education purposes have lower (weekday) occupancy than the Social/recreational purposes
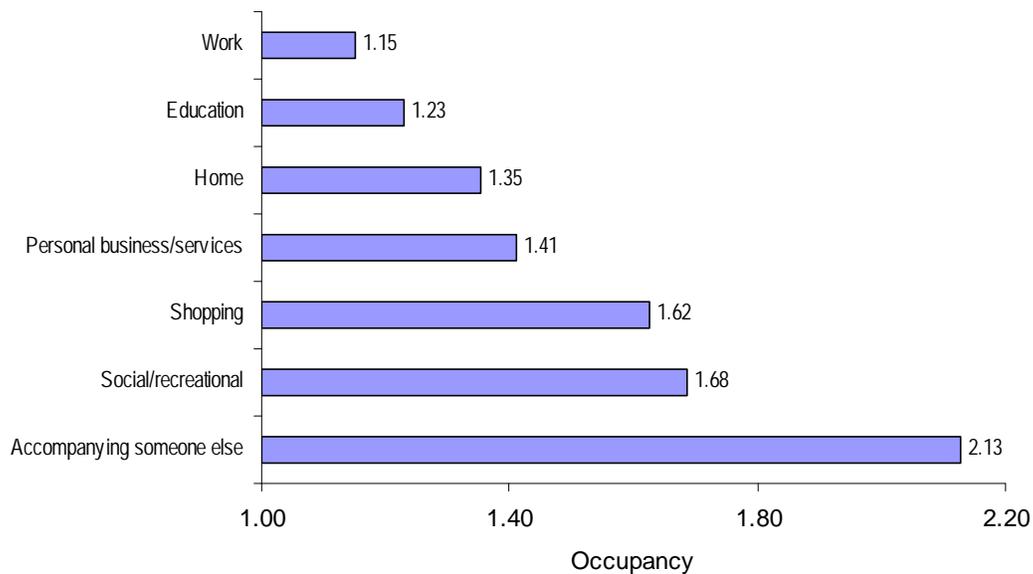
The differences in occupancy related to trip purpose may help explain trends in occupancy. In particular, because occupancy trends emerge over relatively long periods of time, patterns over many years are often analysed. Over such long periods, our results indicate that changes in occupancy may result from major social changes, such as increasing amounts of work in the weekend – where work trips typically engender low occupancy rates – rather than necessarily reflecting "real" changes. Similarly, the opening of major work sites or places of education (e.g., the

Albany university campus on Auckland's North Shore) may lead to a distinctly higher proportion of journeys for Work/Education purposes rather than Social/recreational or Shopping purposes on arterial roads nearby. This change in mix of purpose could be sufficient in itself to explain a substantial reduction in occupancy (and accompanying increase in vehicular traffic), without there necessarily being any real reduction in local use of other modes.

3.2.2 Demographic causes of difference in occupancy

At first sight, gender differences in occupancy do not appear great. For example, including weekends, average occupancy for female drivers is 1.55 compared with 1.50 for males. Greater differences begin to appear when weekdays are analysed separately: 1.48 female, 1.36 male (see

Table 4). In contrast, Saturday shows equal occupancy of 1.83, and Sunday reverses the direction of the difference: 1.90 female, 2.12 male. However, even these figures conceal substantial differences in occupancy type that only emerge when passenger characteristics are measured (see section 3.3).

Pacific peoples and Mäori drivers have higher occupancy (1.73 and 1.63 respectively compared with 1.37 for NZ European/Pakeha). However, these differences are based on relatively small base numbers of drivers in these subgroups[3]. Besides, the differences between ethnic groups diminish when one takes account of the differences in household size and numbers of vehicles per household as discussed below.

Weekday occupancy differences in terms of driver age are not large (ranging from 1.35 to 1.5 for the five age groups in

Table 4). Greater differences become apparent when one considers household type (which reflects stage of life and household size): from 1.15 for Person living alone through to 1.56 for Family with children[4]. In particular, these results suggest that the number of children in a household is a key determinant of total occupancy.

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[3] Though note that an approximate significance test, using the mean occupancy for each driver, shows that differences between ethnic groups are significant: $F(3, 1761)=12.1$, $p<0.001$. The test is only approximate because it does not take full account of the statistical weighting, beyond scaling the weight so that the total weighted sample size matches the total base number of respondents.

[4] An approximate significance test shows these differences to be clearly significant: $F(6,1745)=19.1$, $p<0.001$.

Table 4: Differences (between drivers) by gender, ethnicity, age, household type

	Mean occupancy (weekdays)	Base number of drivers (unweighted)
Total	1.41	*1765*
Gender		
Female	1.48	*871*
Male	1.36	*894*
Ethnicity		
Pacific Peoples	1.73	*70*
NZ Mäori	1.63	*86*
NZ European or Pakeha	1.37	*1238*
Other	1.44	*371*
Age		
15-24	1.40	*207*
25-39	1.47	*626*
40-59	1.35	*682*
60+	1.48	*164*
Household type		
Person living alone	1.15	*162*
Married/de facto couple only	1.31	*466*
Single adults only	1.23	*89*
Family (including extended) with children	1.56	*712*
Family with adults only	1.31	*220*
Single adult living with children	1.51	*58*
Other	1.38	*50*

To show how household **composition** affects vehicle occupancy as opposed to pure household **size**,

Figure 3 simultaneously presents total household size, the number of adults (aged 19+) and the number of children (aged 14 or younger). (The number aged 15-18 are not plotted for clarity—they are an intermediate group who are legally entitled to drive, but relatively rarely do.) Clearly, the increase in occupancy related to household size (reflected in the upward slope of the Total line) is mainly because of the sharp increase associated with the number of children. In contrast, the flat line for number of adults shows relatively little relationship with average weekday occupancy.

Figure 3 Household size affects occupancy mainly through the number of children
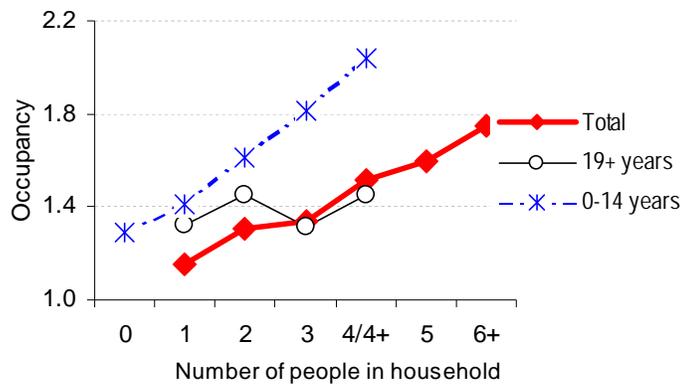
Note: Two of the lines plotted stop at 4+ (i.e., 4 or more) because few households have more than 4 adults or 4 children.

Not surprisingly, drivers from households with more vehicles tend to have lower average occupancy (see Table 5). The relationship is much stronger if one also takes into account household size by calculating the ratio of vehicles to people for each household (e.g., where the household has 1 vehicle and 2 people this ratio = ½ = 0.5).

Table 5: The number of household vehicles has less impact on occupancy than the ratio of vehicles to people

Number of household vehicles	Mean
1	1.56
2	1.39
3	1.37
4–6	1.26
Vehicle:People ratio	
<0.5	1.81
0.5	1.51
0.51–0.99	1.41
1	1.23
>1	1.22

At first sight, driver income (as assessed by total household income) shows little relationship with occupancy (see Figure 4)–it changes only from 1.47 for the group with the lowest household income to 1.34 for the highest income group. Although rarely seen in transport analysis, it is established practice in some social research to test income sensitivity after first adjusting household income for household size. Quite simply, the logic is that a single person household with an income of $50,000 might be relatively price insensitive, but that a household with 2 adults and 4 children with the same total household income might be much more price sensitive. To calculate the adjustments, we used the Revised Jensen Scale (Perry, 1995), which is commonly used in New Zealand for such adjustments. Adjusting household income in this way reveals a clear pattern of higher average occupancy associated with

lower income households (dropping from 1.57 for the lowest income group to 1.22 for the highest income group)[5].

Figure 4 Average weekday occupancy falls as household income (adjusted for household size) increases
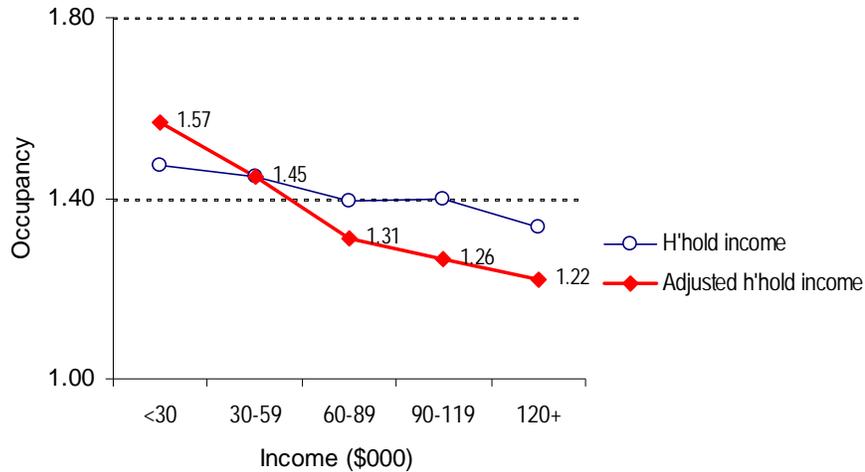
3.3   PASSENGER CHARACTERISTICS OF OCCUPANCY

As shown earlier (section 3.2.2), average occupancy showed only small differences between male and female drivers. However, these averages conceal dramatic differences in passenger characteristics.

Table 6 shows that women drivers have household children as occupants much more often, even on Saturdays and Sundays. In contrast, much of the higher occupancy recorded by men during the weekends derives from men driving much more often when a trip involves more than one household adult (perhaps particularly on Sundays).

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[5] An approximate significance test confirms the significance of these differences: $F(5,1759)=10.1$, $p<0.001$.

Table 6: Passenger characteristics reveal large gender differences

	Gender of driver	
	Female	Male
Weekdays		
Lone driver	68.3%	73.4%
Household adult psgrs only	4.4%	9.6%
Household children (<18) psgrs only	**11.8%**	**2.9%**
Household psgrs only, both adults & children	0.5%	1.7%
Nonhousehold psgrs only	10.4%	8.6%
Undefined; driver did not specify number of occupants	1.0%	2.1%
Other	3.5%	1.8%
Base number of trip legs (unweighted)	*6757*	*7081*
Saturday		
Lone driver	50.9%	47.4%
Household adult psgrs only	**5.5%**	**21.9%**
Household children (<18) psgrs only	**14.3%**	**7.1%**
Household psgrs only, both adults & children	**2.5%**	**8.7%**
Nonhousehold psgrs only	14.5%	10.5%
Undefined; driver did not specify number of occupants	3.0%	1.7%
Other	9.3%	2.8%
Base number of trip legs (unweighted)	*911*	*1550*
Sundays		
Lone driver	50.5%	34.0%
Household adult psgrs only	**6.8%**	**28.0%**
Household children (<18) psgrs only	**10.5%**	**4.7%**
Household psgrs only, both adults & children	**5.3%**	**15.9%**
Nonhousehold psgrs only	19.1%	8.2%
Undefined; driver did not specify number of occupants	0.5%	1.2%
Other	7.4%	7.8%
Base number of trip legs (unweighted)	*611*	*1160*

Similarly, comparing household composition and age groups in terms of passenger characteristics clearly shows the kinds of differences to be expected, particularly with respect to transporting children.

Analysis of car-pooling is of particular interest with respect to reducing congestion at peak times. Given that

Table 7 shows relatively few trips involving both household and nonhousehold passengers (classified as Other), the occupancy type "Nonhousehold passengers only" provides a useful indicator of car-pooling. From

Table 7, it appears that car-pooling (as measured in this way) may be more common in off-peak times (9:30-14:59 and evening) than peak times.

Table 7: Occupancy type by time of day (weekdays)

	Up to 7:30	7:30-9:30	9:30-14:59	15:00-18:29	18:30 and later
			Starting time		
Lone driver	84.1%	73.3%	70.3%	72.3%	60.1%
Household adult psgrs only	7.1%	7.2%	7.1%	6.2%	11.5%
Household children (<18) psgrs only	0.8%	9.2%	6.2%	7.8%	5.5%
Household psgrs only, both adults & children	0.0%	1.2%	0.9%	1.3%	2.6%
Nonhousehold psgrs only	**6.7%**	**6.1%**	**11.3%**	**7.6%**	**14.0%**
Undefined; driver did not specify number of occupants	1.1%	1.3%	1.5%	1.8%	2.7%
Other	0.0%	1.7%	2.6%	3.1%	3.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Base: Unweighted trip legs	*733*	*2273*	*5040*	*3963*	*1817*

The current structure of the database (being founded on trip legs) does not permit us to easily analyse car-pooling in relation to the journey to work because such trips involving nonhousehold passengers could have one of two trip purposes (i.e., Work or Accompanying someone else). To properly analyse car-pooling on the way to work requires linking the trip legs together to form "trip chains", a task we have now started.

4.   SUMMARY AND IMPLICATIONS

4.1   ESTABLISHING BASE VALUES

To our knowledge, this paper is the first detailed analysis of occupancy in New Zealand. Thus, even firmly establishing simple descriptive results such as the overall nationwide average occupancy of 1.69 for 1997/98 (for cars and vans/utes/4-wheel drives) is useful (as done at the start, section 1).

Given a vacuum of detailed information about occupancy, surprisingly varied figures are being mentioned. For example: "We still have 1.1 people in the average car trip, a woefully inefficient use of vehicles..."(*EnergyWise News,* June 2003, p 13) versus "the average occupancy of cars in New Zealand is 2.15 persons" (Becken, 2002, p 11). Both of these statements might be true in a specific context, for example, time of day (before 7:30 a.m., average occupancy is 1.17), day of week (average occupancy on Sunday is 2.15), or trip purpose (average occupancy of work trips is 1.1 to 1.2). However, they are clearly not reflecting the overall occupancy rate on New Zealand roads.

Other important base values established are average urban occupancy of 1.41 (weekdays), 1.83 (Saturdays), and 2.05 (Sundays).

4.2 IMPROVING INTERPRETATION OF OCCUPANCY TRENDS

The relationships presented here between driver characteristics and occupancy indicate that trends in occupancy, as established by roadside observation over many years, will be affected by driver characteristics not measured in such studies. Naturally, occupancy trends will also be affected by transport-specific changes (e.g., falling real vehicle and fuel prices), but these are beyond the purview of the present paper.

The key findings of our descriptive analysis of the characteristics of vehicle occupancy can be summarised as follows:

1. Vehicle occupancy is very different in the weekends. Hence, it will often be prudent to analyse and interpret weekday occupancy separately from weekend occupancy. In addition, it is likely that changes in transport infrastructure or travel demand management policies will have different effects on weekend occupancy than on weekday occupancy. Also, note that occupancy is a little higher on Sundays than Saturdays.

2. Major demographic trends such as population ageing and smaller household sizes have been shown to have significant (downward) effects on vehicle occupancy. The number of children in a household strongly determines average vehicle occupancy. This is consistent with U.S. research on occupancy (Chandrasekharan & Goulias, 1999) which found "life-cycle stage of the household" to be an important predictor of joint rather than solo trips.

3. Changes in the trip purpose "mix" can increase or decrease occupancy. Greater numbers of Social/recreational trips (average weekday occupancy of 1.68) will increase occupancy, whereas greater numbers of Work trips (average weekday occupancy of 1.15) will reduce occupancy. In addition to resulting from land use changes (e.g., opening of major new retail centres, places of education, work sites, new subdivisions), changes in trip purpose mix may also be a long-term general trend. For example, a recent U.S. analysis showed that work trips accounted for around 25% of all person trips in 1969 but only 15% in 2001. Americans are now doing many more trips for other purposes (U.S. Department of Transportation, 2003). New Zealand may well have a parallel changing mix of trip purposes, and to some extent, this can mask the underlying trend of decreasing occupancy.

4. Describing the characteristics of passengers highlighted significant differences in the relationship between gender and vehicle occupancy. For example, average occupancy for male and female drivers varies little, but the type of occupancy (in terms of passengers) is very different. Women drive much more when the only passengers are children, and this difference even holds for Saturdays and Sundays.

4.3 TRANSPORTATION MODELLING

Patterns of occupancy found here might also assist with building and calibration of transportation models (e.g., the models New Zealand Regional Councils use to forecast trips by time of day, mode, and trip purpose). For example, one could compare modelled occupancies by trip purpose and time of day with the observed occupancies we have found.

4.4 TRAVEL DEMAND MANAGEMENT (TDM)

O'Fallon et al. (in press) recently reported a stated preference study of 732 peak-time morning car commuters (to work or their place of education) in Auckland, Wellington and Christchurch. That study concerned the impact of possible policy tools discouraging car use (e.g., cordon tolls, parking restrictions, increased parking charges) and those encouraging alternative modes (e.g., improved public transport services, reduced public transport fares, high occupancy vehicle lanes), and the constraints affecting people's mode choice. Comparing the current analysis with that study enables us to consider the potential impact of such policy tools on vehicle occupancy, and to consider the extent to which the two studies are consistent.

The stated preference study did not suggest that such policy tools would greatly increase car occupancy for the journey to work. Overall, only 2% of the choices made showed commuters switching from driving a car to becoming a car passenger, and 1% to car-pooling. When choosing change, the most common choice was to switch to public transport (24%). (Note that a majority of the choices, 67%, quite realistically continued their current regular pattern of driving despite the various policy interventions.)

Given that so few choices reflecting increased vehicle occupancy were made, these could not be modelled reliably in detail. A few factors were modelled and found significant.

First, a design variable reflecting the installation of a high occupancy vehicle (HOV) lane reducing travel times by 35% did lead to a significant increase in car-pooling in Auckland. This result is consistent with a U.S. study (Charles River Associates, 1998) which found that HOV facilities may encourage car-pooling, rather than just offering a convenient alternative for those who already car pool. In New Zealand, car-pooling is likely to be more attractive in Auckland than Wellington, because public transport is more problematic for more commuters in Auckland (a smaller percentage in Auckland work in the CBD, which is better served by public transport than outlying areas).

Second, males were significantly less likely to switch to becoming passengers or to car-pooling. Consistent with this result, the current analysis of occupancy shows that women are much more likely to be passengers in household vehicles.

Third, drivers were more likely to switch to car-pooling for trips over 20 km. As mentioned earlier, we are unable to analyse the relationship between car-pooling and the journey to work (including trip length) using the NZTS database in its current form.

The current analysis of occupancy and our stated preference study show that the presence of children in a household strongly influences occupancy and mode choice. The current analysis shows that the number of children in a household was a clear determinant of average vehicle occupancy whereas the number of adults in household was not. In the stated preference study, children were particularly associated with less switching by drivers to "walkPT" (i.e., walking and then taking public transport). However, driving a child to school was positively associated with choice of "drivePT" (i.e., drive, park and ride public transport) in Wellington (where this modal combination is well-established).

In addition, our earlier work with walking school bus networks (O'Fallon et al., 2002) revealed that providing parents with safe alternative options for their child's travel to school via "walking school bus networks" could also have the positive effect of reducing car use. In a Christchurch-based trial involving four schools, 62% of the families reduced their car use before 9 a.m. by an average of 20 minutes per week.

Interventions such as walking school buses would eliminate some relatively unnecessary "high occupancy" vehicle trips from the roading network. However, this could create the perception of decreasing vehicle occupancy if the remaining trips were single-occupant vehicles on their way to work.

It appears that the most "successful" policy tools in our stated preference study – cordon tolls, distance charges, extra parking charges or restrictions – would decrease the amount of single-occupant vehicle commuting by replacing it with the use of alternative modes (particularly public transport), rather than increasing vehicle occupancy. From the perspective of public decision- and policy-makers, the key result would be the reduction in the number of vehicles on the road during peak periods, irrespective of whether this is due to increased occupancy or a switch to more environmentally friendly modes.

Other interventions not investigated in our stated preference study may be more effective if the specific goal is increasing vehicle occupancy. For example, car-pooling or "Rideshare" programmes can be established on-site for a single large organisation, or alternatively for a group of smaller organisations located in the same vicinity (using websites to facilitate drivers and passengers establishing contact). New Zealand's Energy Efficiency and Conservation Authority (EECA) has developed and provided "Rideshare" software now in use by some tertiary education institutions and regional/city councils to facilitate such interventions.

Personalised marketing initiatives to encourage travel in a more environmentally friendly manner may also be useful in encouraging higher vehicle occupancy. By getting people to think about how and when they travel, initiatives such as "travel blending", "TravelSmart", and journey planners may encourage more car sharing and/or trip chaining, as well the use of alternative modes.

4.5   EXTENSIONS OF THIS ANALYSIS

Chandrasekharan & Goulias (1999) also point to an important possible extension of the current study of occupancy: regression models simultaneously analysing the effect of several variables on the occupancy of each trip. For simplicity and because this is (to our knowledge) the first major analysis of occupancy in New Zealand, our analysis here generally has described the impact of one variable at a time on vehicle occupancy.

A second major extension fits with other work we will be completing in the next year: analysis in terms of trip chains rather than trip legs. In particular, the trip chain approach promises to deliver a clearer analysis of car-pooling, and could also clarify the impact of driving children to school.

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